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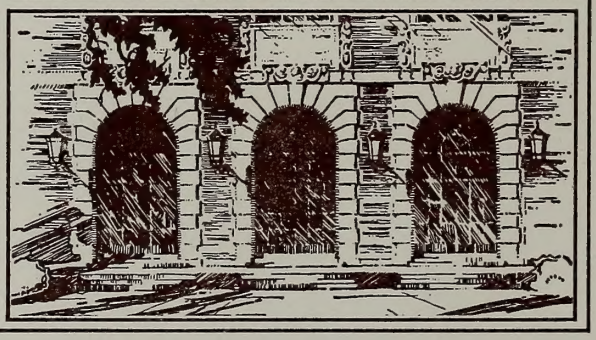

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QUARTERLY TECHNICAL PROGRESS REPORT

January, February, March 1969

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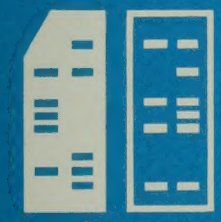

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN · URBANA, ILLINOIS

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QUARTERLY TECHNICAL PROGRESS REPORT

January, February, March 1969

Department of Computer Science
University of Illinois at Urbana-Champaign
Urbana, Illinois 61801

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract NR 048-102/6-15-67 Code 437, W. J. Poppelbaum, Principal Investigator).

Summary

John Esch discusses the conversion of machine values into variable values for the purposes of checkout and display. In keeping with the current craze of intials he has renamed this Stochastic Computing project RASCEL (sic), for explanation of which please see the report. David Ring is building a small machine to test the ideas of Bundle Processing; he describes its main features. Finally, Tak Katoh proposes a new type of data compression scheme for encoding line drawings.

M. Faiman

1.1 Stochastic Computing

1.1.1 Reconstruction of Variable Values from CRPS's

The major problem with debugging, testing and using the RASCEL system (Regular Array of Stochastic Computing Element Logic) is in determining what numbers the CRPS's inside RASCEL actually represent. For example, if $\underline{a} = a_n/a_d$ is represented in RASCEL by $A_n = [a_n, a_n']$ and $A_d = [a_d, a_d']$, then to find $\underline{a}$ from A_n and A_d these CRPS's must be sampled to get an estimate of their machine values, a_n' and a_d'. After that , the machine values must be mapped onto their corresponding variable values, a_n and a_d, which must be divided to obtain $\underline{a}$. When there are many numbers so represented, this process becomes impossible for most people to do mentally.

In the RASCEL system this is done automatically by decoding, dividing, scaling and display circuits. The decoding circuits amount to two subtractors of the form described in DCS-QTPR, 1, 1967, and shown in Figure 1. Their outputs consist of sign magnitude numbers with, for the above example, magnitudes $|a_n|/2$ and $|a_d|/2$. The divider is an Addie (invented by Brian Gains), modified to fit the RASCEL system, and consists of an up-down counter, binary number size comparator, random binary number generator and associated circuitry as shown in Figure 2. This circuit is called a Subbie and, when connected as shown in Figure 3, can be used to divide $|a_n|/2$ by $|a_d|/2$ to obtain $\underline{a}$.

Because the magnitude of $\underline{a}$ can exceed unity, additional circuits are used to scale $\underline{a}$. This is done by detecting when certain values occur in the up-down counter of the Subbie and then changing a scale factor by 10 or 10^{-1}, depending on whether $\underline{a}$ is getting too large or too small.

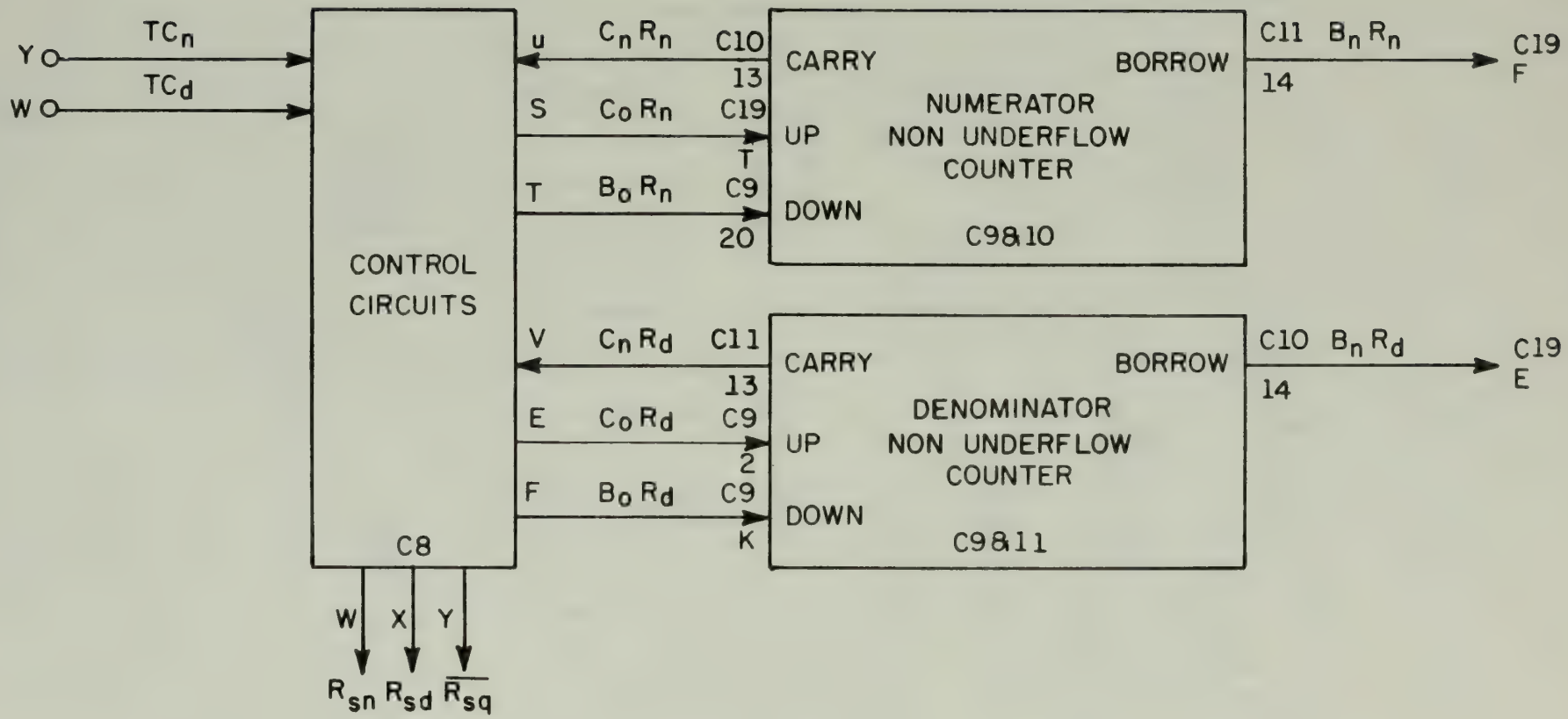


Figure 1. Dual Subtractor

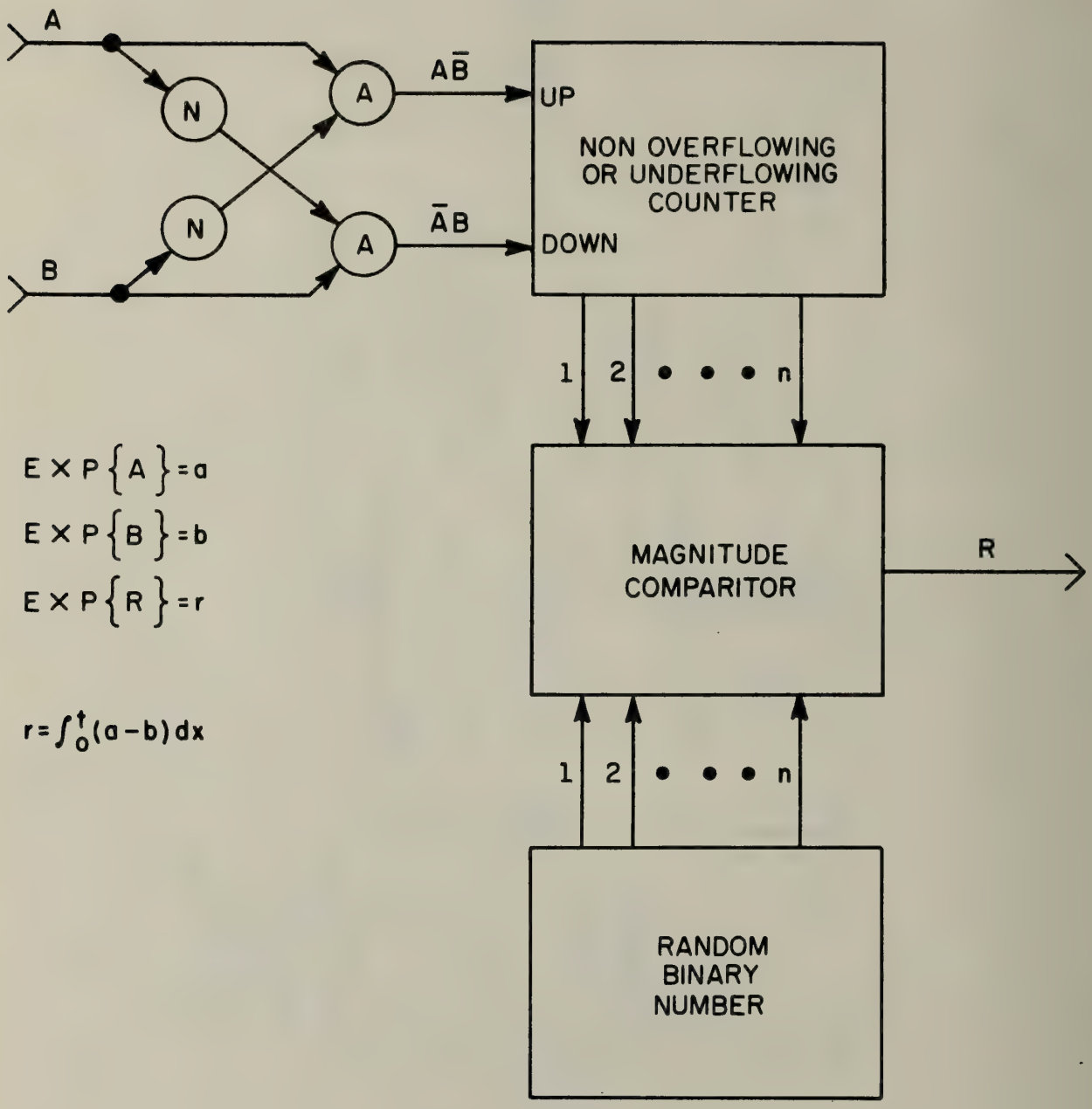


Figure 2. The Subbie or Modified Addie.

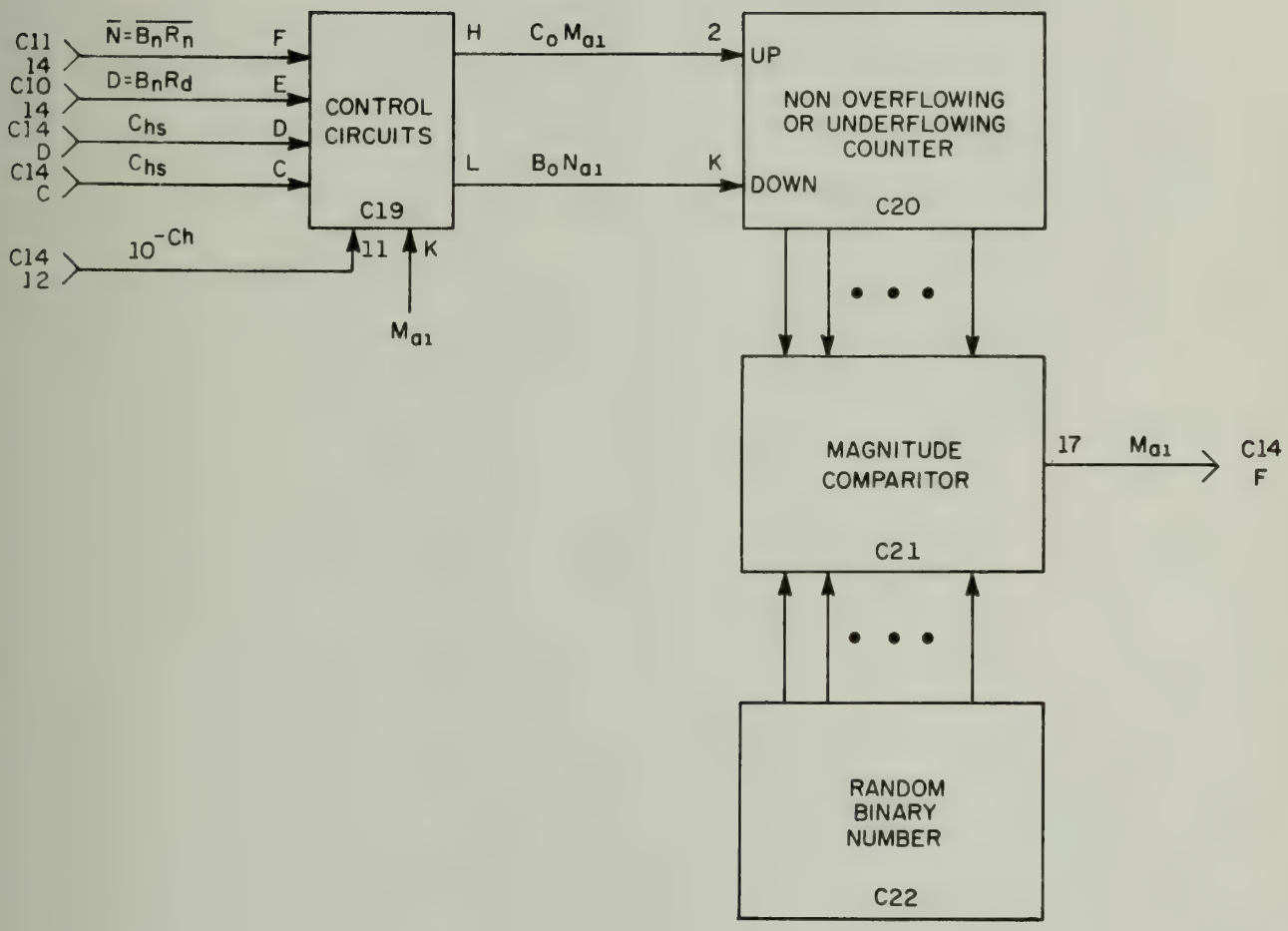


Figure 3. Subbie used to divide.

This scale factor is then fed into the division Subbie to keep a in the range 0.1 to 1, as depicted in Figure 4.

The result of all these circuits is a number in the form $\pm Ma \times 10^{\pm Ch}$ where $0 \leq Ma \leq 1$ and $0 \leq Ch \leq 3$. The Ma signal is a CRPS and is sampled by a counter. At the end of each counting period the contents of the counter are transferred to a storage register and the counter is reset, as shown in Figure 5. The storage register, signs and Ch signals all drive a NIXIE tube display.

The interconnection of the decoding, dividing, scaling and display circuits is illustrated in Figure 6. The labeling and signal names on all the figures in this section correspond to actual printed circuit card pins and names in RASCEL.

John Esch

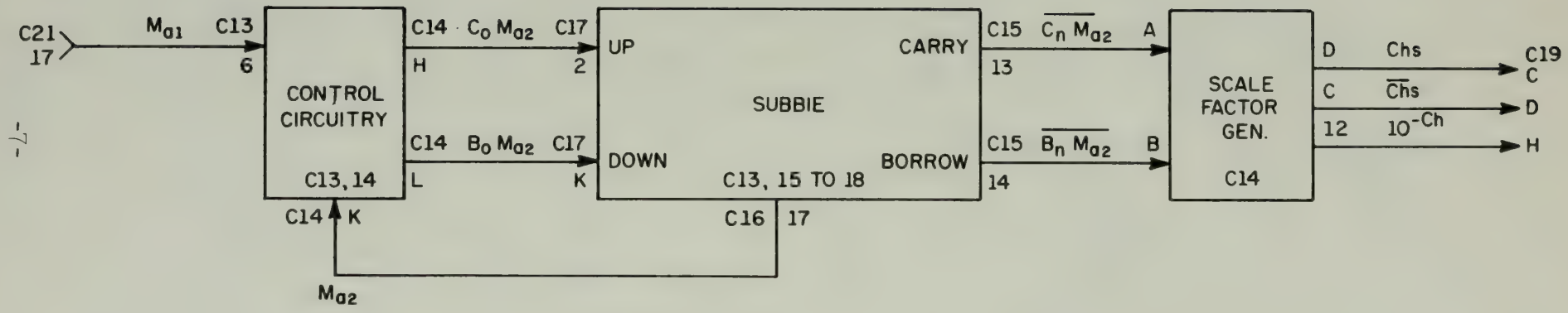


Figure 4. The Scale Factor Generator

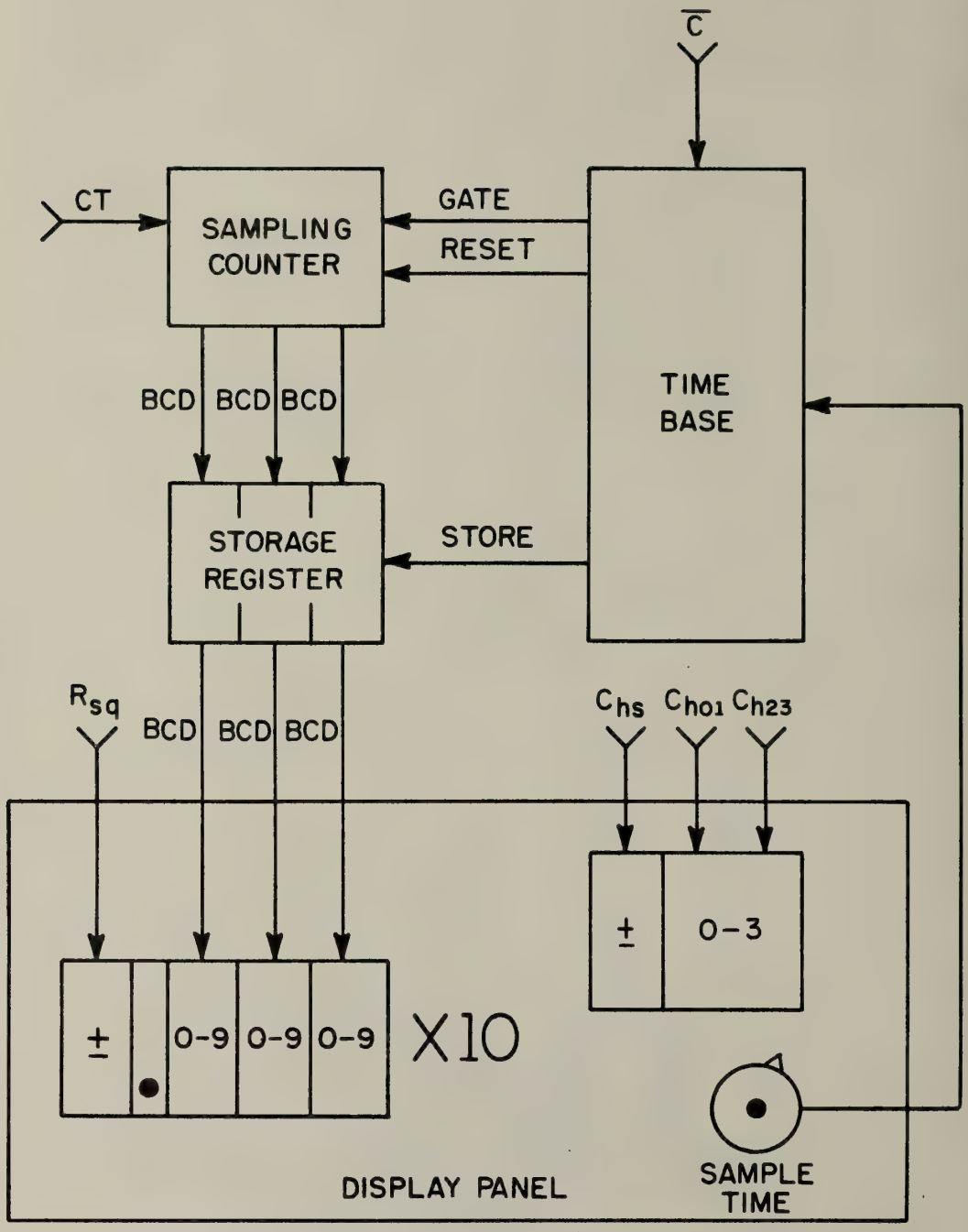


Figure 5. The Display Circuits

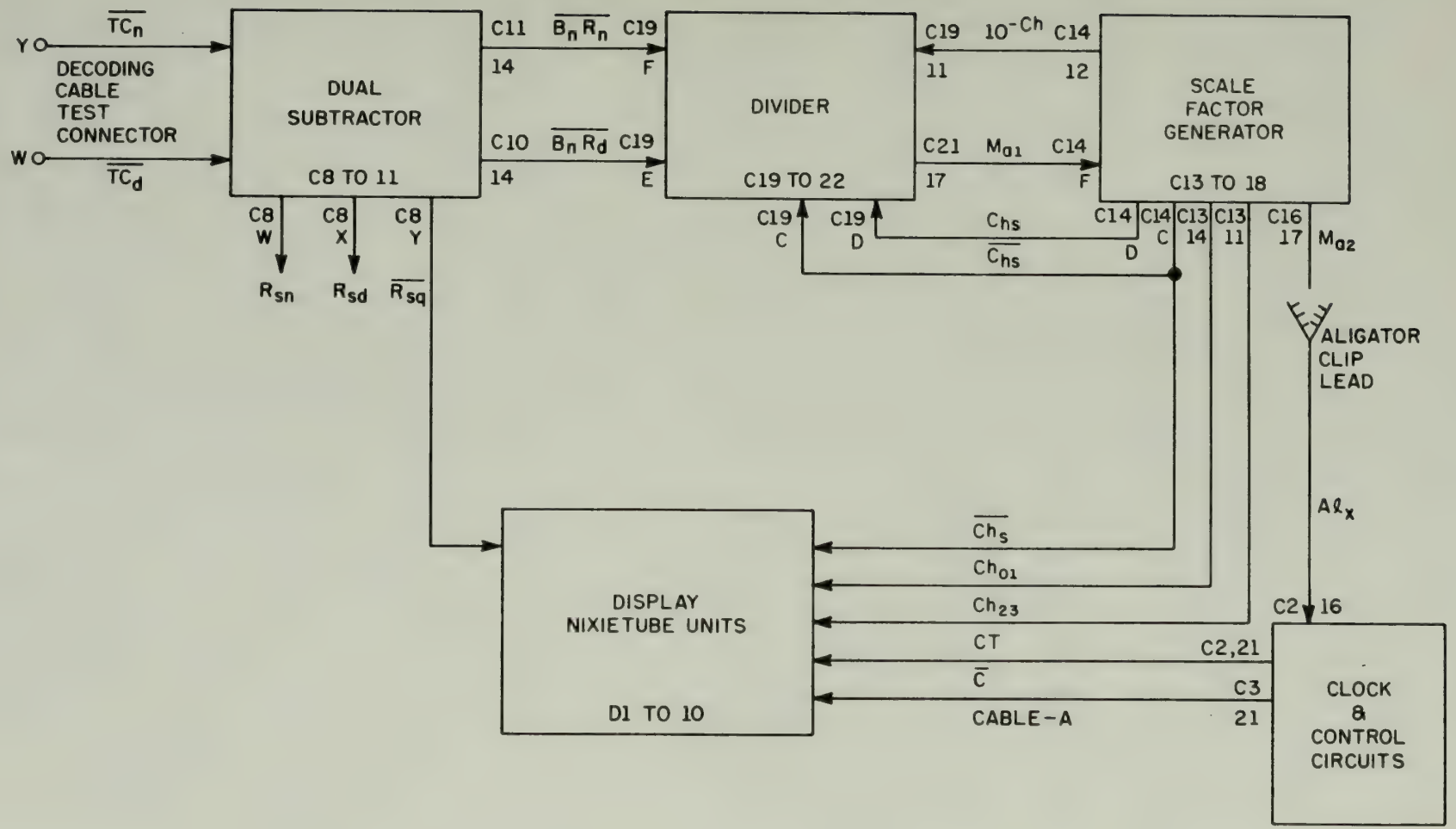


Figure 6. Block diagram of decoding and display circuits.

1.2 Bundle Processing (Project No. 21)

1.2.1 Summary

This quarter it was decided to build a machine to demonstrate the feasibility of bundle processing. The machine is to perform the operations of addition, subtraction, and multiplication. It is not required to divide or solve the attrition problem.

1.2.2 Machine Structure

The machine uses bundles having 100 wires. There are two input bundles, each connected to a 10 x 10 matrix of switches. All outputs are shown in two ways: a 10 x 10 matrix of lights, and a meter that decodes into an analog type output.

In order to implement subtraction easily, the following mapping between machine values (x) and variable values (y) was chosen:

$$y = 2x - 1, \quad \text{or} \quad x = (y + 1)/2$$

$$0 \leq x \leq 1, \qquad -1 \leq y \leq 1$$

x being the fraction of wires carrying a '1' in a bundle.

With this representation, negation is accomplished simply by inverting the signals on all wires in a bundle.

Addition is performed by merging two bundles into one having 200 wires. At random, 100 wires are chosen to be the output bundle. If the individual ratios of the two bundles are x_1 and x_2, the ratio of the combined bundle is $(x_1 + x_2)/2$. Randomly taking half of the wires does not change this ratio, so the output will also be $(x_1 + x_2)/2$. This is the attrition problem discussed in the last quarterly report.

Subtraction is performed by inverting the wires from one bundle before merging, but again, due to the attrition problem, the output is halved. At this time, the machine does not attempt to solve this problem.

Multiplication needs a more complicated solution. The individual wires of the input bundles are selected by pairs - one wire from each bundle. Each wire of the pair is the input to an equivalence circuit. The output wire from the equivalence circuit is one of the wires of the product bundle. For this machine, there are 100 pairs using 100 equivalence circuits in parallel.

Division is not considered with this machine, but it can be done using a different representation. If two bundles are used, one each for a numerator and denominator, division may be performed by multiplying the appropriate bundles. In that representation, addition and subtraction may be done, but are more involved, and the attrition problem is still present.

1.2.3 Decoders

To be able to tell the number on any bundle, a decoder must be used. Two types are used in parallel on this machine. In the first, each wire simply drives a light bulb. The second decoder uses a meter that reads from -1 to +1 and shows the number being represented.

All of the wires in the bundle are tied to one point called NODE through large resistors, as shown in Figure 1.

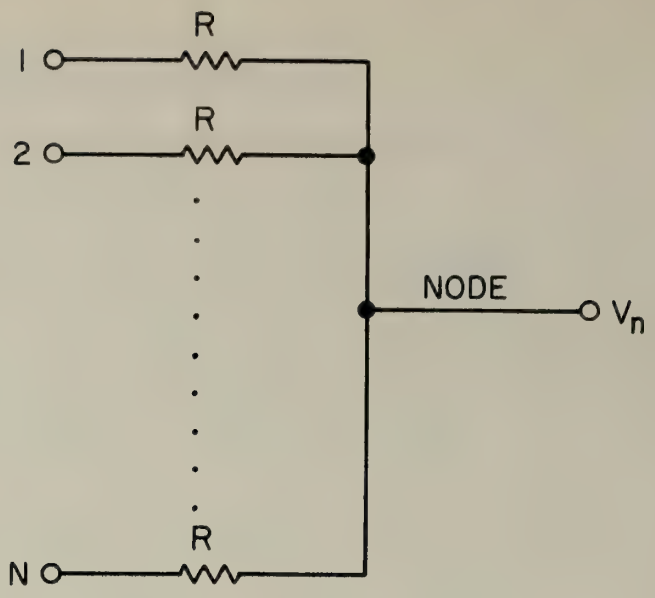


Figure 1. Bundle Decoder.

If n of the inputs are at the "1" level, V_1, and the rest are at the "0" level, V_0, then

$$V_n = V_0 + \frac{n}{N}(V_1 - V_0)$$

$$= B + An, \text{ say}$$

i.e., V_n is a linear function of the number of wires at the "1" level. Since the output is into a meter, an operational amplifier is used to handle the gain A and offset B.

In experimenting with the gates, it was found that the V_0 and V_1, levels varied as much as one volt among the different integrated circuits. The Texas Instruments SN 7401N Quad 2-input NAND with open collector output was found to have the most accurate levels of the types tested, so all operations use them as the final output stage. $V_1 = V_{cc}$ and $V_0 = 0.16 \pm 0.02$ volt. It turned out later that such accuracy is probably not necessary.

The decoders used on the input bundles did not need the 7401's because $V_1 = V_{cc}$ and $V_0 = 0$. These voltages come from the busses through the switches to the decoders.

The effect of the small variation in V_0 upon V_n can be easily calculated. If one of the "0" levels is changed from V_0 to $V_0 + \Delta V_0$, the change in output is reduced by a factor N:

$$\Delta V_n = \frac{\Delta V_0}{N}$$

At this time, the machine is under construction. The inputs have been wired and their decoders work except for a few bad light bulbs and transistors. The multiplier is wired, but is untested, and the adder and subtractor are being wired now.

Dave Ring

1.3 Half-order Approximation of Lines and Curves of Drawings for Bandwidth Compression (Project No. 22)

The system to be proposed approximates lines and curves of drawings by straight lines with some fixed angles.

An ordinary black and white picture is characterized by three parameters: brightness and two positional coordinates. The brightness can be defined as a function of the position such that the brightness at $(x,y) = f(x,y)$.

Conventional T.V. scanning yields a mapping which maps the two positional coordinates into the time domain by sampling along one positional coordinate, the y coordinate in Figure 1. There is a data compression method, which consists of sampling $g(t)$ at $t = t_0, t_1 \ldots$ and fitting some polynomials to it, which is called zero-order and first-order polynomial interpolation, where $g(t)$ is the video signal of $f(x,y)$.

1.3.1 Polynomial Interpolation [1]

The process of after-the-fact polynomial curve fitting in order to eliminate redundant data samples is termed interpolation.

The functional operation of the zero-order polynomial interpolator algorithm is shown in Figure 2. In the zero-order interpolator a horizontal line is used to represent the largest set of consecutive data samples within a prescribed peak-error tolerance and the transmitted sample is computed at the end of the redundant set. The transmitted sample t' is computed as the average between the most positive sample t_u and most negative sample t_l in the set. All samples in the set are within the prescribed peak-error tolerance from the transmitted sample.

As the name implies, the first-order polynomial interpolator algorithm approximates the data with a first-order polynomial curve.

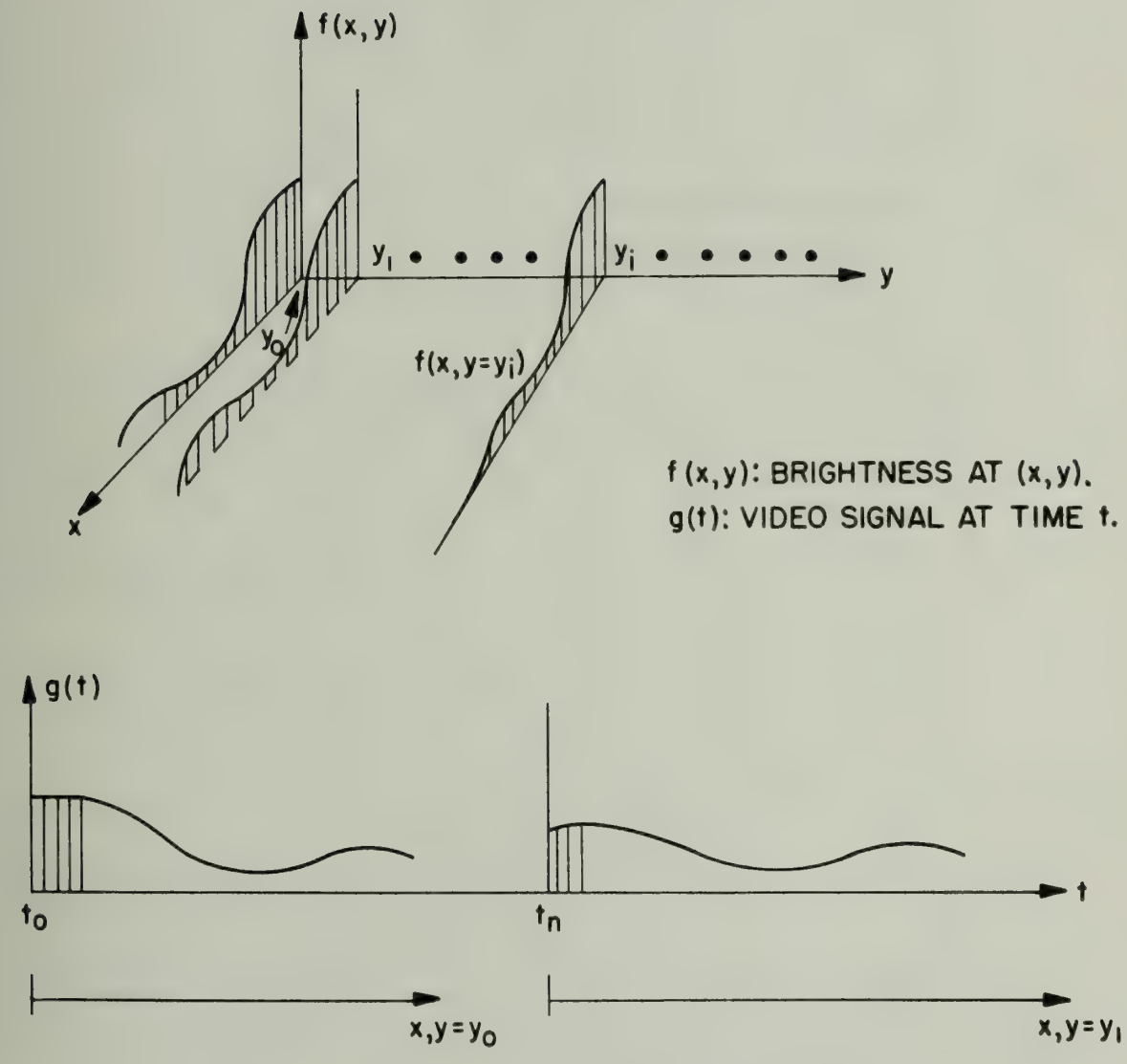


Figure 1. Position and time relation for video signal.

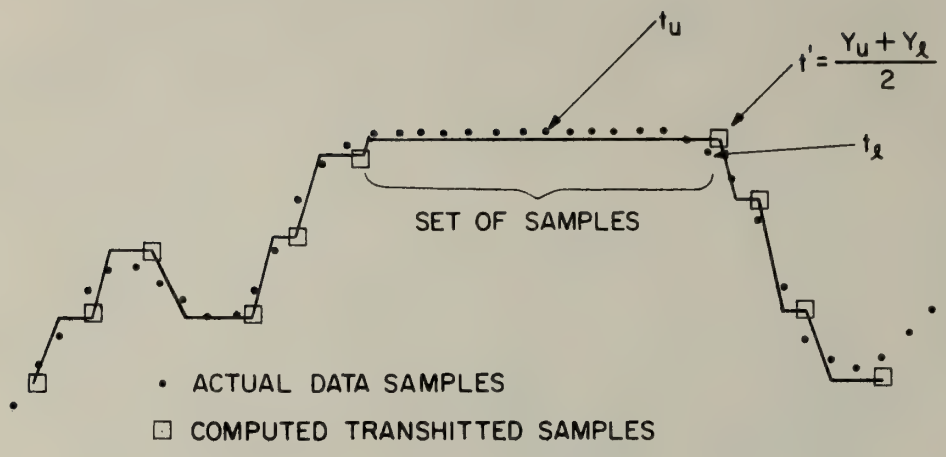


Figure 2. Zero-order polynomial interpolator.

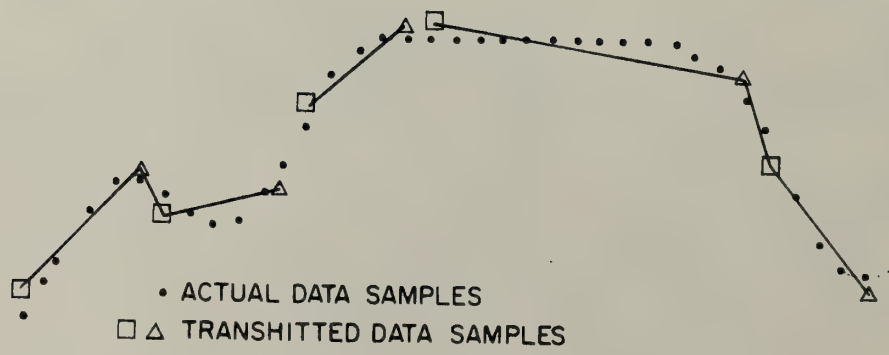


Figure 3. First-order polynomial interpolator.

Several methods exist for representing redundant samples by a straight line segment. To achieve the largest compression ratio, it is necessary to select a line segment that is within some small percent of as many samples as possible. This optimum first-order algorithm requires freedom of both the starting and end points of the straight line, resulting in four degrees of freedom. The performance of this optimum process is shown in Figure 3. It is seen that both the starting and ending points of each line are computed values such that the length of each line is maximum for the peak-error guaranteed. Also, the end point of one line segment can be connected with a straight line to the beginning of the following line segment.

1. C. M. Kortman, "Redundancy Reduction -- A Practical Method of Data Compression," Proc. of IEEE, Vol. 55, No. 3, March, 1967.

1.3.2 Proposed System

1.3.2.1 Introduction

Let T be a set of sampling times for a picture: $T = \{t_0, t_1 \cdots t_{n-1}, t_n \cdots t_{n^2-1}\}$ and let there be n sample times for $y = y_i$ where $0 \leq i < n$. Suppose that the picture is square so that the picture is partitioned into n^2 small square regions and that the brightness of each small region is sampled in time. Let $T_0 = \{t: g(t) = 0, t \epsilon T\}$ and

$$T_1 = \{t: g(t) = 1, t \epsilon T\}$$

where g(t) is the time domain representation of the video signal at time t. Then $T_0 \cup T_1 = T$ and $T_0 \cap T_1 = \emptyset$.

Suppose that analog signals are used to indicate brightness. Then, for this case there are only two values 1 and 0. n^2 analog

signals are needed to represent a picture, since T has n^2 elements.

Let N be the number of elements in T_1. Suppose that analog signals are used to indicate the sampling time. Then N analog signals are needed to represent the picture, since every analog signal received at the receiver has the value of $g(t) = 1$, and $g(t_i) = 1$ indicates a black spot is sampled at $t = t_i$. In general, for drawings, the number of elements in T_1 is much smaller than the number of elements in T_0. Hence $n^2 \gg N$. (For that matter, $n^2 \gg 2N$ and therefore even if two analog signals are used to indicate each sampled time, data compression is still obtained.)

Suppose $T_1 = \{t_0, t_5, t_6, t_7, t_8, t_9, t_{10}, t_{20}, t_n, t_{2n}, t_{3n}\}$, then T_1 has 20 elements and 20 analog signals needed to encode them. Instead of encoding every element of T_1, some elements can be grouped together and encoded as a group. Let (t_i, j, k) be the group name where t_i indicates the first element in the group, k indicates that there are k elements in the group and j indicates that every j^{th} element starting with t_i is in the group. For example, T_1 above contains three groups: $(t_0, n, 4)$, $(t_5, 1, 6)$ and $(t_{20}, 0, 1)$. For each group three analog signals are needed since t_i, j and k must be indicated. Where there is only one element in a group, only two signals will be required of course. For convenience, we shall define a group's name as (t_i, j, k) even when $j = 0$. Then T_1' is

$$T_1' = \{(t_0, n, 4), (t_5, 1, 6), (t_{20}, 0, 1)\}$$

where T_1' has the same elements as T_1 but elements of T_1' are encoded by groups and thus only nine analog signals are needed. If no group is named more than once and if any proper subset of another group is not grouped in a different way (for example $(t_5, 2, 3)$ and $(t_6, 2, 3)$ which are

both in $(t_5,1,6)$) and if there are very few groups which contain one or two elements, then the grouping operation produces data compression.

However, this is not the only grouping technique. Grouping by polynomial fitting on the x-y domain with a curve following scan was the first system proposed. It was decided that this was not a suitable method for our purposes because of the difficulties involved in curve following and because a large reference memory is required in order to determine whether a curve has been followed and grouped or not.

In order to eliminate the reference memory, let us return to the (t_i,j,k) grouping method and suppose $j = 1$. Then knowing $j = 1$ for all groups, t_i and k are the only parameters to be encoded and this is exactly the same as the zero-order interpolator or the first-order interpolator (they are the same for this case of video signals g(t)). Since the grouping operation is done as time goes by, any element of T_1 appears in only one group and therefore the reference memory is not needed.

1.3.2.2 Description of the proposed system

The proposed system is one which superimposes the (t_i,j,k) grouping method on the x-y domain of a picture every θ degrees of rotation. In other words, the system first scans horizontally and forms groups. It then rotates the scan θ radians and forms new groups. This process is repeated M times where M is the largest integer less than $\frac{180^\circ}{\theta}$. The name "frame-zero" pertains to the horizontal or "normal" scan and "frame-θ" to the scan which is rotated θ radians clockwise. Similarly "frame-2θ" refers to the frame which has been rotated by 2θ.

Let a small group be a group consisting of a few elements. Then small groups in one frame can be parts of larger groups in other frames.

As mentioned before, this is not desirable. In order to eliminate small groups, introduce an integer K and suppose that any group containing fewer than K elements is not recognized as a group. Then short lines in a pictrue may not appear in any of the M frames. Of course, short lines are not as important as long lines in a drawing. (If they are important, they can be drawn longer.) Clearly, the value of K will be dependent on θ. Figure 4 shows the video signal g(t) for a line of the drawing which is being scanned. Suppose a line of the drawing focused on the photoconductive surface of a vidicon has the width w' and the scanning beam on the surface has the width w. Then by providing a suitable threshold for the video signal the length of the projection of the line of the drawing onto the scanning beam is $w'/\sin\varphi$ and is equal to the length of the total number of elements in that group for the present frame. Therefore $k = \frac{w'}{w \sin\varphi}$ where w = length of one element for a square array.

Suppose $2\varphi = \theta$, then the number of elements in the groups $k_{m\theta}$ and $k_{(m+1)\theta}$ in the frame $m\theta$ and the frame $(m+1)\theta$ respectively are equal and then $k_{m\theta} = k_{(m+1)\theta} = \frac{w'}{w\sin(\theta/2)}$. If $K = \frac{w'}{w\sin(\theta/2)}$, then the lines with $\varphi = \theta/2$ are the only lines which are grouped together in two different frames and they are the only groups encoded twice when all M frames are put together. However, the probability of $\varphi = \pm \theta/2$ is very small, since the probability density of lines between $m\theta - \frac{\theta}{2}$ and $m\theta + \frac{\theta}{2}$ is uniform.

Therefore, the proposed system needs at most K/3 times a smaller number of signals than encoding T_1 without grouping, since every group requires three analog signals for encoding in a practical situation. On the average it will be much greater than K/3 times better.

In order to discuss the average case, the average size of a group

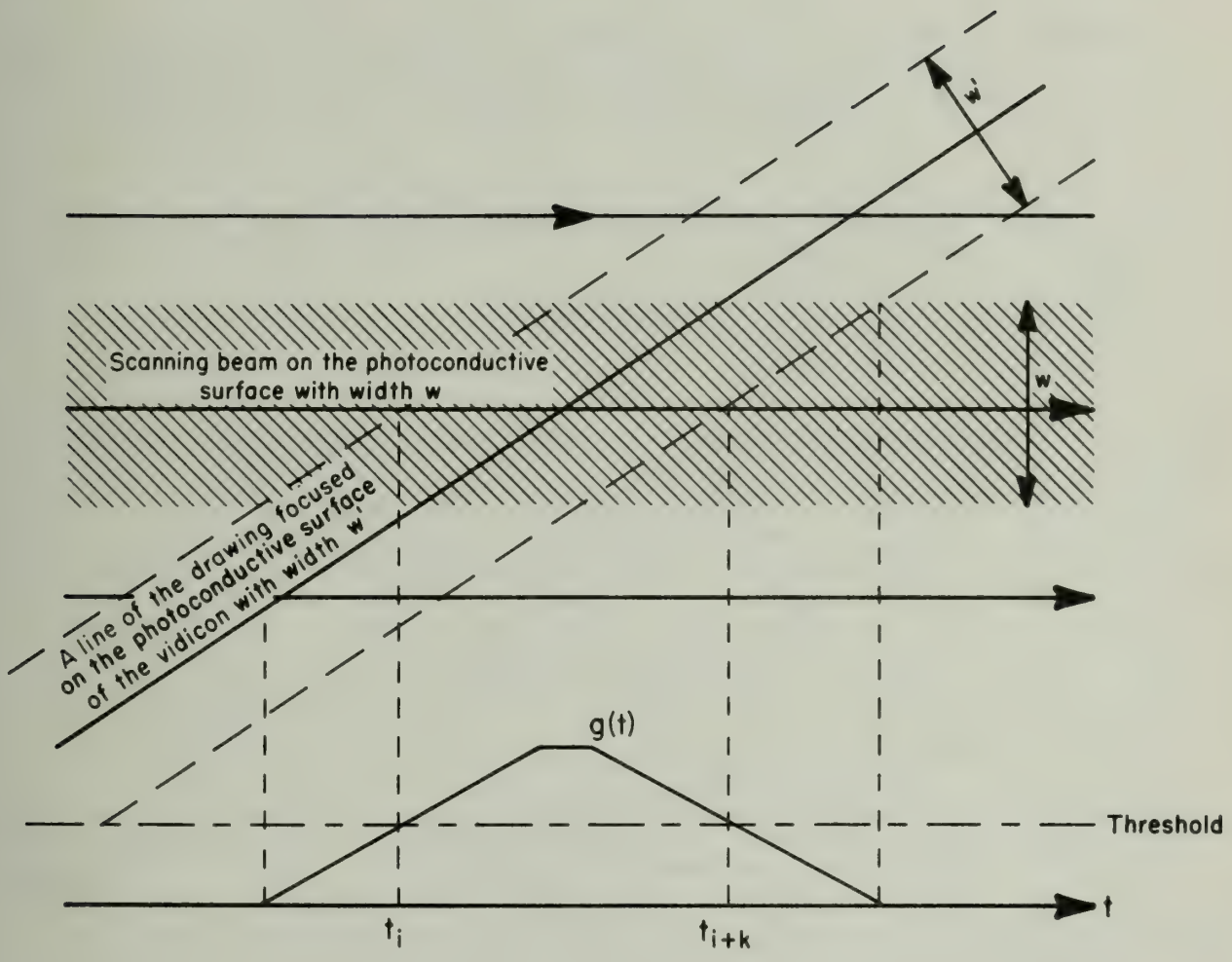


Figure 4. The video signal g(t) of a line of the drawing.

must be found. Since $\mathbf{k} = \frac{w'}{w \cdot \sin\varphi}$,

$$k_{ave} = \frac{\int_{-\frac{\theta}{2}}^{\frac{\theta}{2}} \frac{\omega'}{\omega \sin\varphi} \, d\varphi}{\theta}$$

where we assume $\omega = \omega'$ for convenience. However $\frac{1}{\sin\varphi} \to \infty$ as $\varphi \to 0$ and $k_{ave} \to \infty$. By assuming that all groups have n_{ave} elements where $n_{ave} = \frac{1}{n} \int_0^n x \, dx = \frac{1}{2}n$, we can establish a bound on k_{ave}. Then there must be an α such that $\frac{1}{\sin\alpha} = n_{ave}$. Then

$$\mathbf{k}_{ave} = \frac{\int_{-\frac{\theta}{2}}^{-\alpha} \frac{1}{\sin\varphi} \, d\varphi + \int_{-\alpha}^{\alpha} n_{ave} \, d\varphi + \int_{\alpha}^{\frac{\theta}{2}} \frac{1}{\sin\varphi} \, d\varphi}{\theta}$$

$$= \frac{\int_0^{\alpha} n_{ave} \, d\varphi + \int_{\alpha}^{\frac{\theta}{2}} \frac{1}{\sin\varphi} \, d\varphi}{\frac{\theta}{2}}$$

$$= \frac{n_{ave} \cdot \alpha + \int_{\alpha}^{\frac{\theta}{2}} \frac{1}{\sin\varphi} \, d\varphi}{\frac{\theta}{2}}$$

For $n_{ave} \gg 1$, $\frac{1}{\sin\alpha} = n_{ave} \gg 1$, $\alpha \simeq \sin\alpha \simeq \frac{1}{n_{ave}}$,

$$k_{ave} = \frac{2}{\theta}\left(n_{ave} \cdot \frac{1}{n_{ave}} + \left[\ln\left|\tan\frac{x}{2}\right|\right]_{\alpha}^{\frac{\theta}{2}}\right)$$

$$= \frac{2}{\theta}\left[1 + \ln\left|\tan\frac{\theta}{4}\right| - \ln\left|\tan\frac{\alpha}{2}\right|\right]$$

$$= \frac{2}{\theta}\left[1 + \ln\left(2n_{ave}\left|\tan\frac{\theta}{4}\right|\right)\right]$$

For example, suppose $n = 500$ and $\theta = \frac{\pi}{16}$, then $n_{ave} = 250$ and

$$K = \frac{1}{\left(\sin\frac{\pi}{32}\right)} \simeq 10$$

$$k_{ave} = \frac{32}{\pi}[1 + \ln 25] \simeq 43$$

Therefore, the proposed system provides at least $\frac{10}{3}$ times as much data compression as encoding T_1 without the grouping operation and in the average case it provides about 14 times more reduction.

1.3.2.3 Bandwidth compression

Bandwidth compression is defined as any technique which reduces the bandwidth needed to transmit a given amount of information in a given time.

If the time required to transmit the information is fixed and all signals are spread out evenly, then the terms, data compression and bandwidth compression are interchangeable.

If the encoded signals for an entire picture are transmitted allowing the same time for transmitting the information in T_1 with the grouping operation and without it, then the former needs $\frac{k_{ave}}{3}$ times less bandwidth than the latter. In the example above, $\frac{k_{ave}}{3} = 14.3$.

Tak Katoh

1.4 Miscellaneous

1.4.1 Light Pen Development

Unsatisfactory performance of the light pen on the Tri-color Cartograph merited further development in this area. Problems with temperature stability of the pen circuit required changing the germanium transistor to silicon. After further biasing modifications the circuit in Figure 1 was used. This circuit gives a 9 volt pulse out. From preliminary tests, the circuit seems to be more sensitive than the old pen circuit. The enable switch brings up the raster intensity so that the light pen may see it. Work is currently being done on the pen optics.

A new contact switch was built for the enable line. The new switch apparently doesn't disturb other circuitry as much as the old one did, relieving the noise transmission problem.

Donald Hanson

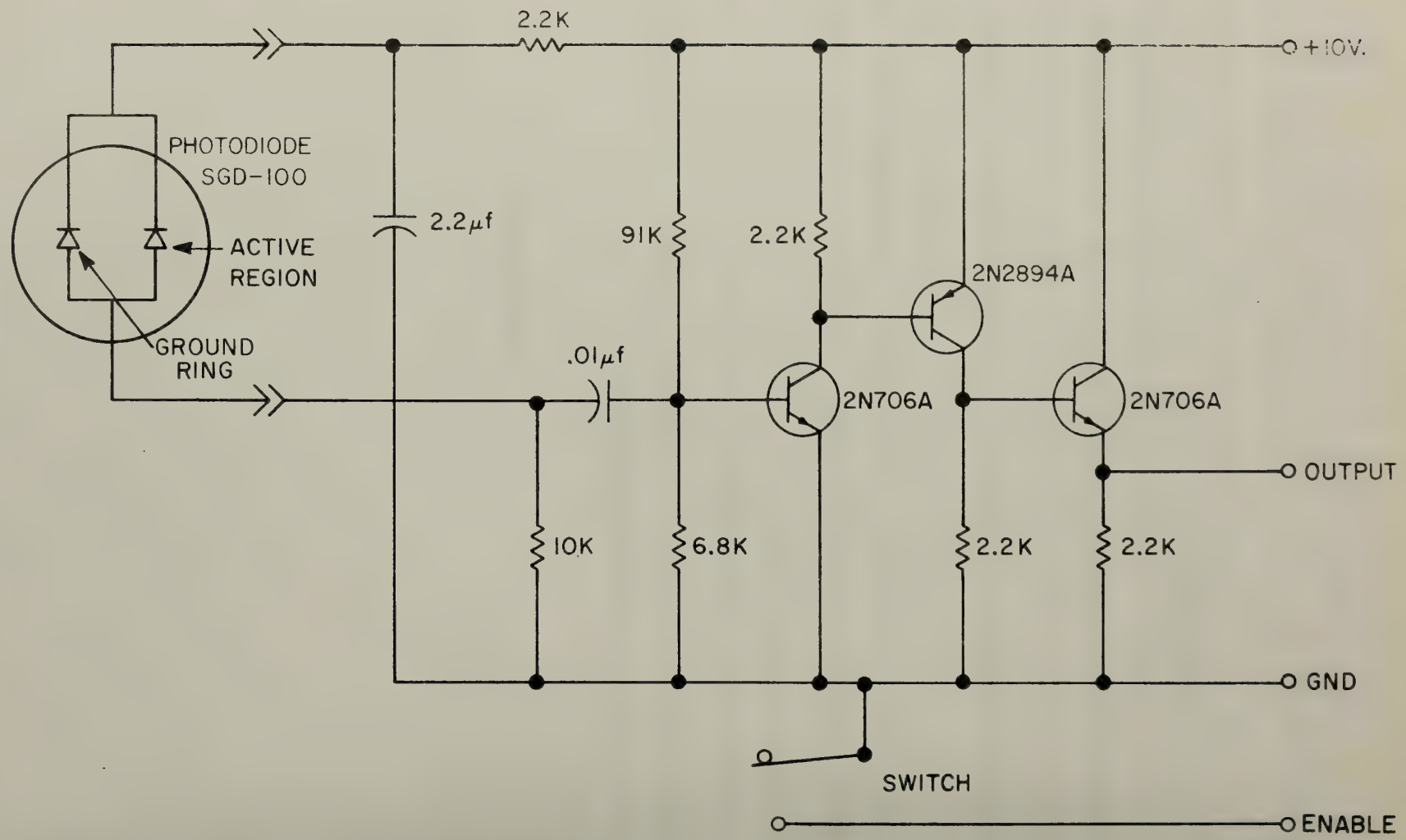


Figure 1. Light Pen Circuit.

2. HARDWARE SYSTEMS RESEARCH

(Supported in part by the Atomic Energy Commission under Contract US AEC AT (11-1) 1469, W. J. Poppelbaum, Principal Investigator.)

Summary

David Casasent and Douglas Sand report on several items of progress with OLFT - measurement of crystal resolution and charge decay time, and circuits for the dynamic operation of beam shutter and erase gun. David Rollenhagen describes the vidicon protection circuitry for the VISTA system and comments on the variation of picture contrast with scan rate. The Functional Encoding project has been renamed ORBIT; a solution to the problem of transmitting horizontal lines is outlined by Peter Oberbeck. For Transformatrix Lawrence Ryan and Orin Marvel describe the 5-bit adder and a 2 x 2 model of the system. Larry Wallman reports on progress with the special CRT containing a lenticular screen for the 3D Television project. Finally, there is a series of short reports on the subsystems of Stereomatrix: coefficient computer (Richard Cheng), observer's position detector (Charles Pirnat) and cursor generator (Terry Quarton).

M. Faiman

2.1 OLFT (Project No. 12)

2.1.1 General Progress

A short series of resolution tests were undertaken, using a fresh crystal and the bar generator described in the previous quarterly report. Interpretation of the results is complicated by a number of factors, including definite evidence of crystal "aging", so that the results are somewhat inconclusive. However, maximum resolution observed was about 100 cycles per inch for a 10 mil crystal thickness. More extensive tests are planned for the near future.

A procedure was developed for easily measuring the crystal time constant and surface potential under dynamic operating conditions. This procedure is discussed below.

A single - frame video storage device (an "Alphechon") has been obtained and the necessary support system (logic and drive circuits) is being built and tested by Dick Ohran and Al Irwin. Initial results are promising, but more circuit development is required for adequate performance.

The beam shutter and erase gun have now been integrated into the system. The circuits developed for sequential pulsed operation are described in separate sections, below. To facilitate the operation of the erase gun, a simple secondary-electron collector ring was built and attached to the crystal mount. The collector ring is held at a positive potential (from 100 to 400 volts) to allow monitoring the secondary electron current as well as the target leakage current. The complex interaction between erase-gun potential, collector-ring potential, and target current will be investigated and discussed in more detail in a subsequent report.

2.1.2 Crystal Time Constant

The crystal charge - decay time constant $\tau = \epsilon\rho$ is a critical system parameter, since it determines the "storage time" for a charge pattern as well as the surface potential obtained for a given write-gun beam current. Several experimental values of the dielectric constant ϵ and the resistivity ρ have been published; the value of ϵ is fairly constant but the range of ρ covers two orders of magnitude, and the resulting time constant can be anything from 10ms to 1s. This is unfortunate since good storage time requires a large τ, preferably greater than 50ms (two or more video frames).

The wide range of the observed value of ρ has been attributed to variations in crystal purity, in addition to evidence of a strong temperature dependence. Thus it will be necessary to determine the value of τ for several - if not all - crystals and operating conditions to be used. In addition, since the half-wave voltage of KDP is about 7000 V, one might expect a significant amount of joule heating under actual (dynamic) operating conditions, so that a "worst-case" value of τ should be determined.

A simple procedure has been developed for evaluating τ under dynamic operating conditions. The write beam, scanned in a standard raster pattern about 2 cm square, deposits a uniform charge pattern onto the crystal. At each point on the surface the potential is exponentially decaying, with time constant τ, and is periodically "refreshed" at the field rate (60 Hz) by the write beam. This exponential decay can be observed on an oscilloscope if the uncollimated laser beam (about 2mm in diameter) is passed through the crystal, through a crossed analyzer, and focused onto a photodiode. By measuring the decay time (between write "pulses") and the maximum and minimum values of light intensity, a reasonable estimate of τ can be obtained. However, if τ is long compared with the write-pulse

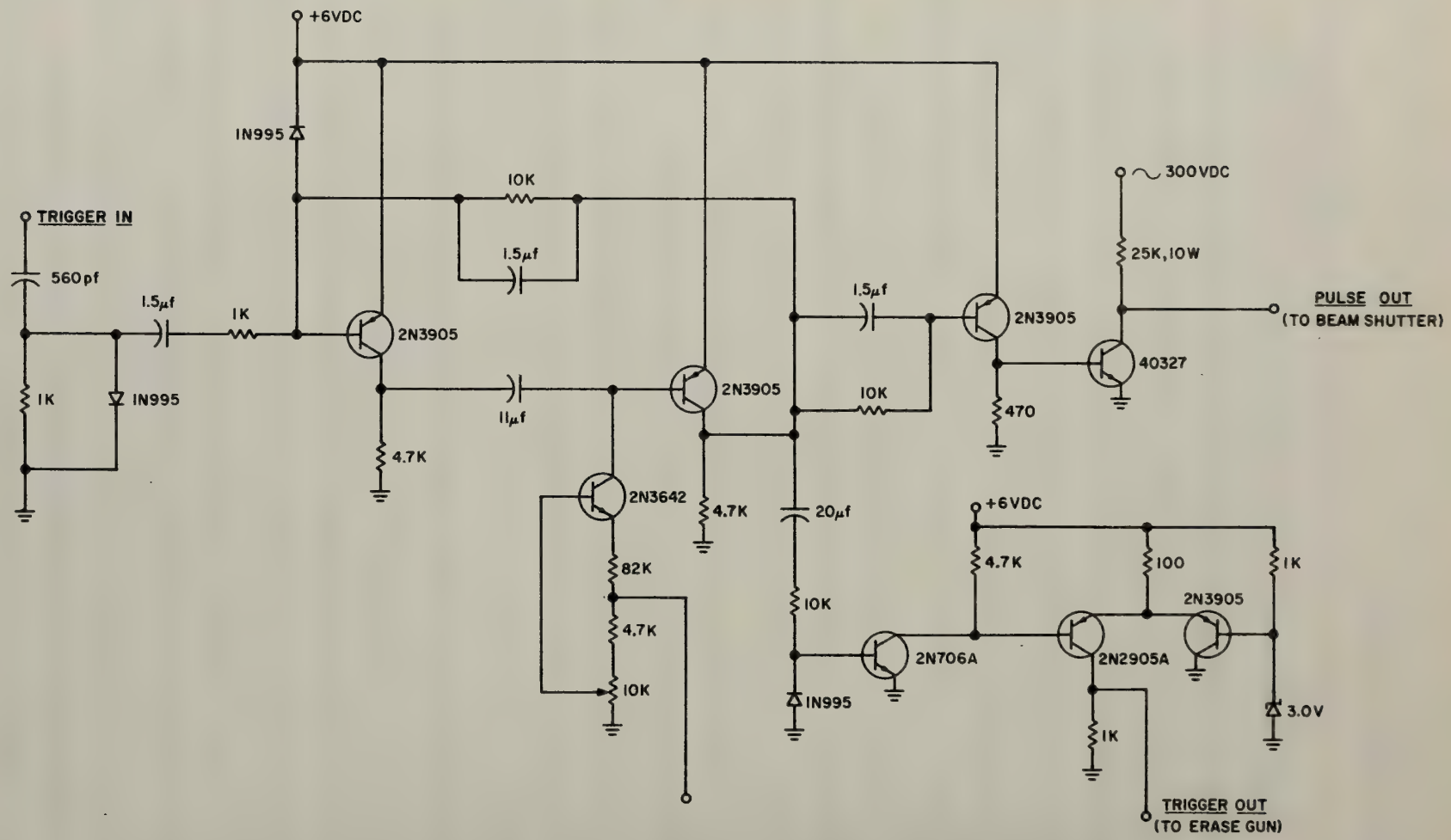


Figure 1. Beam Shutter Drive Circuit

period, the observation error can be quite large. Using this procedure τ was determined for the sample crystal presently in the vacuum chamber. The observed value of τ ranged from about 125 ms at low write current (about 500 volts surface potential) to about 90 ms at high write current (about 2500 volts surface potential). Although these values of τ are acceptable, it is evident that τ varies under different operating conditions.

2.1.3 Beam-Shutter Drive Circuit

The present version of the beam-shutter drive circuit is shown in Figure 1. It consists of a simple collector-coupled monostable which generates a high voltage pulse for the beam shutter, when triggered by a pulse occurring at the end of the television frame period. The laser beam is "on" during the pulse period, which is variable from about 0.5 ms to 3 ms to allow for various picture intensities. At the end of the pulse period a fast rise-time pulse is generated for triggering the erase-gun monostable.

2.1.4 Erase Gun Pulse Circuit

The erase gun is to be pulsed "on" at the end of each television frame (after the light pulse has occurred) to prepare the crystal surface for a new charge pattern. It was determined that the erase gun can deposit up to 2mA of current uniformly distributed over the target - this is sufficient to erase the crystal completely in about 0.5 ms. A floating monostable circuit was constructed to provide the necessary erase pulse.

The erase gun circuit is shown in Figure 2 and consists of controls for bias potentials and a monostable pulse circuit controlling the erase "on" duration. The cathode potential V_k (nominally about 2kV) is

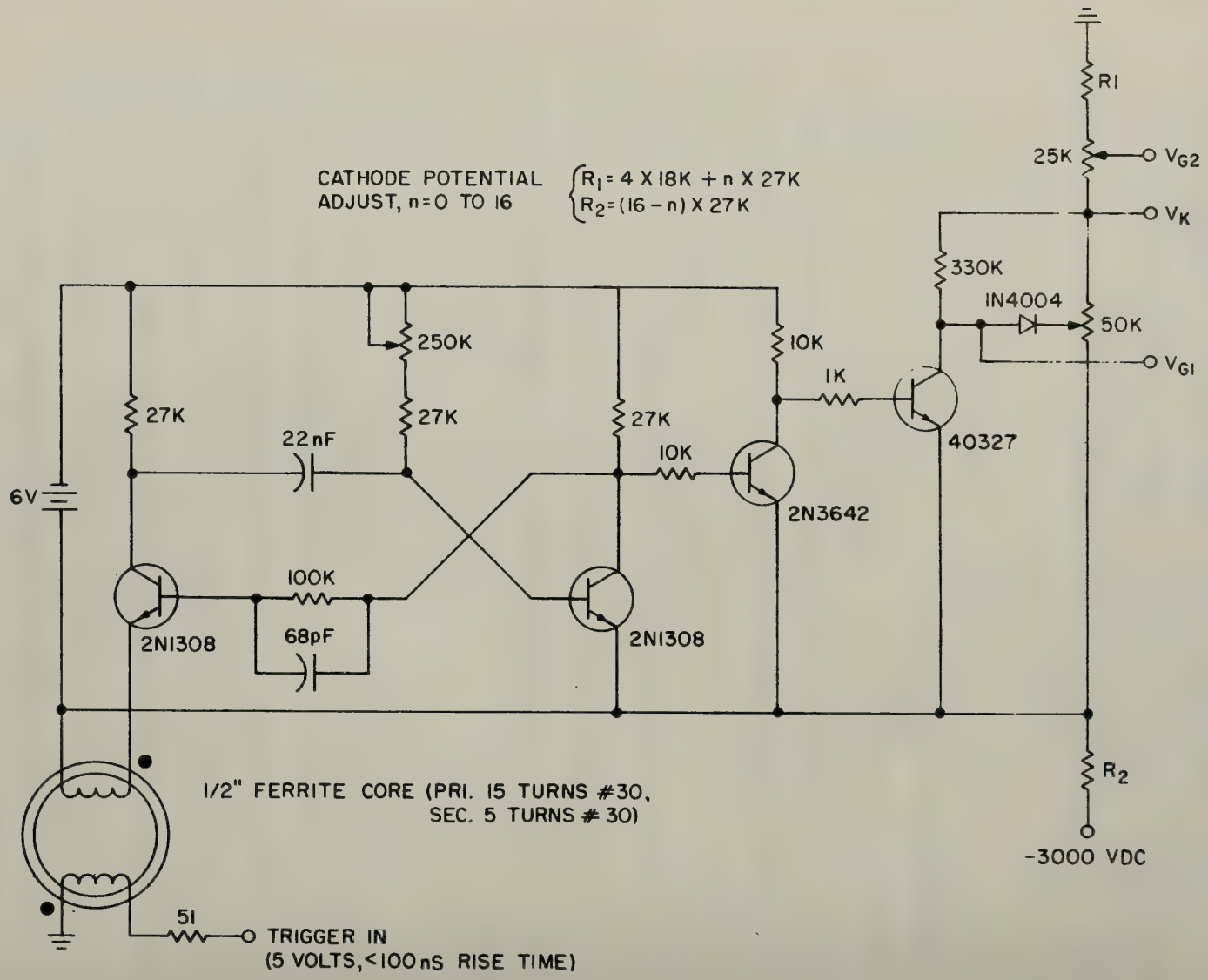


Figure 2. Erase Gun Monostable Circuit

adjustable - to maximize secondary emission - and is determined by a resistor chain controlled by a 17-position high-voltage switch. The grid bias controls and the pulse circuit are floating at cathode potential, so that the monostable must be triggered by an isolation network. At first, a coupling capacitor and low-pass filter were used for isolation, but the poor regulation and large ripple (20 volts) of the power supply caused spurious response. Finally, a pulse transformer was constructed as shown and works quite well, except that a fast rise-time trigger pulse is required. This trigger pulse is supplied by the beam shutter pulse circuit.

Dave Casasent

Doug Sand

2.2 VISTA (Project No. 14)

2.2.1 Variable Scan Television Camera

The preamplifier with gain and filter control circuitry was completed and tested. The mechanical design of the camera was completed and the camera was built. The camera, in its completed form, contains eight circuit cards with the following designation:

	Circuit Description	No. of Boards
1.	Preamplifier, Gain and Filter Control	2
2.	High Voltage Power Supply	1
3.	Vertical Deflection Amplifier	1
4.	Horizontal Deflection Amplifier	1
5.	Gain Range Discriminator	2
6.	Video Amplifier and Cable Driver, Filament Voltage Regulator, Vidicon Protection and Blanking Circuitry	1

All but the last card have been discussed in previous reports. Number 6 in the above list is a pot pourri of miscellaneous circuitry. The Video Amplifier and Cable Driver is a simple common base amplifier in conjunction with an emitter follower. Gain and dc level adjustments are provided. The Filament Voltage Regulator is a simple emitter follower whose base voltage is regulated by a zener diode. The only circuit worthy of detailed discussion on this card is the Vidicon Protection Circuitry. This and another card located in the system card rack, whose function is similar, will be discussed in the following two sections.

2.2.2 Vidicon Protection in the event of Horizontal Scan Failure

The problem of vidicon protection is compounded by the variable scan rate nature of the system. In a single scan rate system, slope detection applied to the horizontal voltage ramp is a simple and useful approach. In such a scheme, when the voltage amplitude corresponding to the first derivative of the ramp falls below a predetermined value, a blanking voltage is applied to the vidicon to prevent burning the target. This technique, with several simple modifications, has been applied to the case of the variable rate scan. Figures 1 and 2 show all the circuitry located on this card. The particular circuit in question is composed of the two differential amplifiers together with their related components shown in Figure 1. The .001 microfarad capacitor and the 10 kilohm resistor tied to ground constitute the differentiating network. The differentiated voltage is compared with a reference via the first differential amplifier. When the threshold is exceeded, an output pulse is applied to the logic elements and the following integrating network. These elements prevent the circuit from reacting during horizontal retrace, or that portion of the ramp with negative slope. The protection circuit may blank the cathode of the vidicon only when the blanking input is a logical "1". The time delay due to the differentiating stage prevented use of the protection circuit for driving the blanking signal directly.

2.2.3 Vidicon Protection in the event of Vertical Scan Failure

The stair-step nature of the vertical ramp dictated a different scheme for protection of the vidicon. The nine binary inputs to the D/A converter, which produce the vertical deflection waveform, are monitored collectively. Each input is applied to a differentiating network, and the

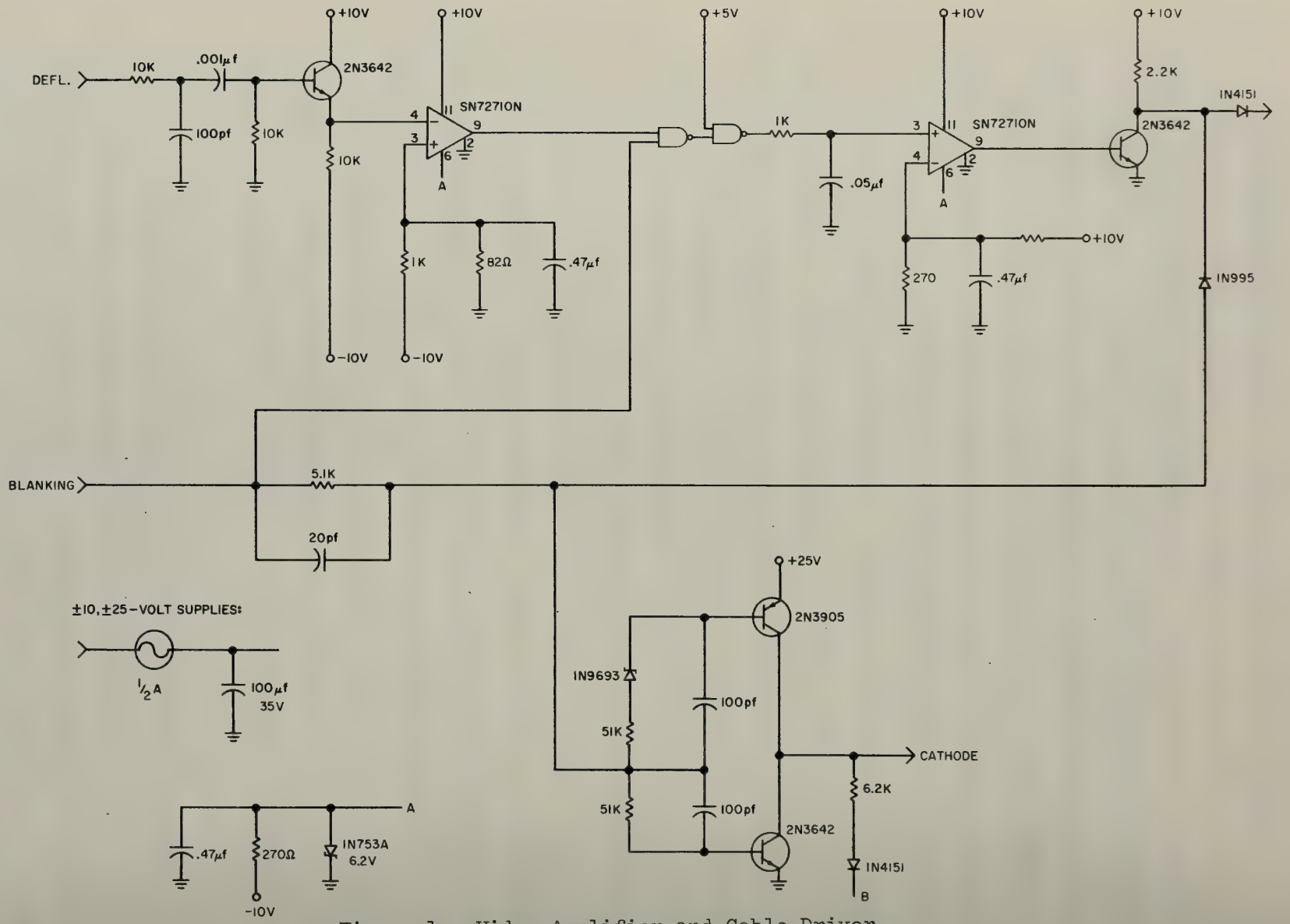


Figure 1. Video Amplifier and Cable Driver, Filament Voltage Regualtor, Vidicon Protection and Blanking Circuitry

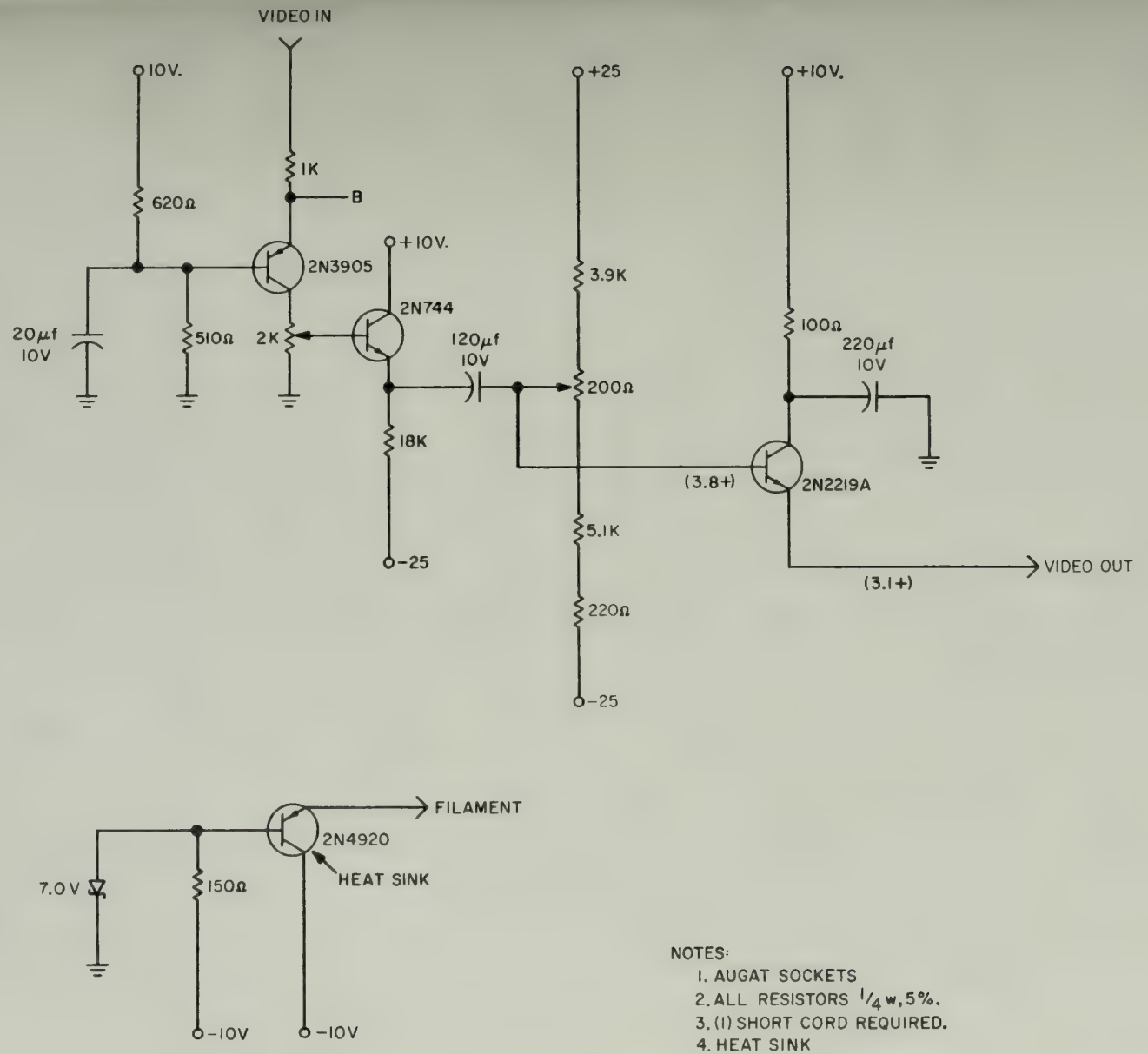


Figure 2. Continuation of Figure 1.

combined output is compared with the horizontal blanking signal. If at least one of the binary inputs changes state, in either direction, a flip-flop will be reset. If no change occurs, indicating that the vertical waveform has not changed between two successive scans, the flip-flop will not be reset, and the cathode of the vidicon will remain blanked. Figure 3 shows the complete circuit. This scheme is obviously not infallible, for the fault could lie in the D/A converter. A trade-off between complexity and probable failure rate resulted in the choice of this scheme.

2.2.4 Camera Performance in conjunction with the Variable Persistence Monitor

The variable scan camera seems to be operating up to expectations, although a quantitative measure of its performance (resolution, gray scale, etc.) has not yet been possible due to the nature of the display device. It is hoped that a Hewlett-Packard 20 MHz large-screen x-y display device may be obtained for testing purposes.

An amplifier was designed to drive the z-axis input of the variable persistence monitor due to the large signal level required. The amplifier is a wideband common base configuration with a gain of ten and a dc restoration stage.

At reduced scan rates, even as low as 2:1 reduction, the resulting flicker was very objectionable, as anticipated. The program control has not been fully wired, so an evaluation of the picture quality with a moving raster is not yet possible.

A feature worthy of note is the contrast enhancement at reduced scan rates. The light evidently integrates on the vidicon target for a longer time at reduced rates, thus resulting in a larger signal output. This lends support for the fact that some light intensity modulation (automatic f-stop reduction at reduced scan rates) will be necessary.

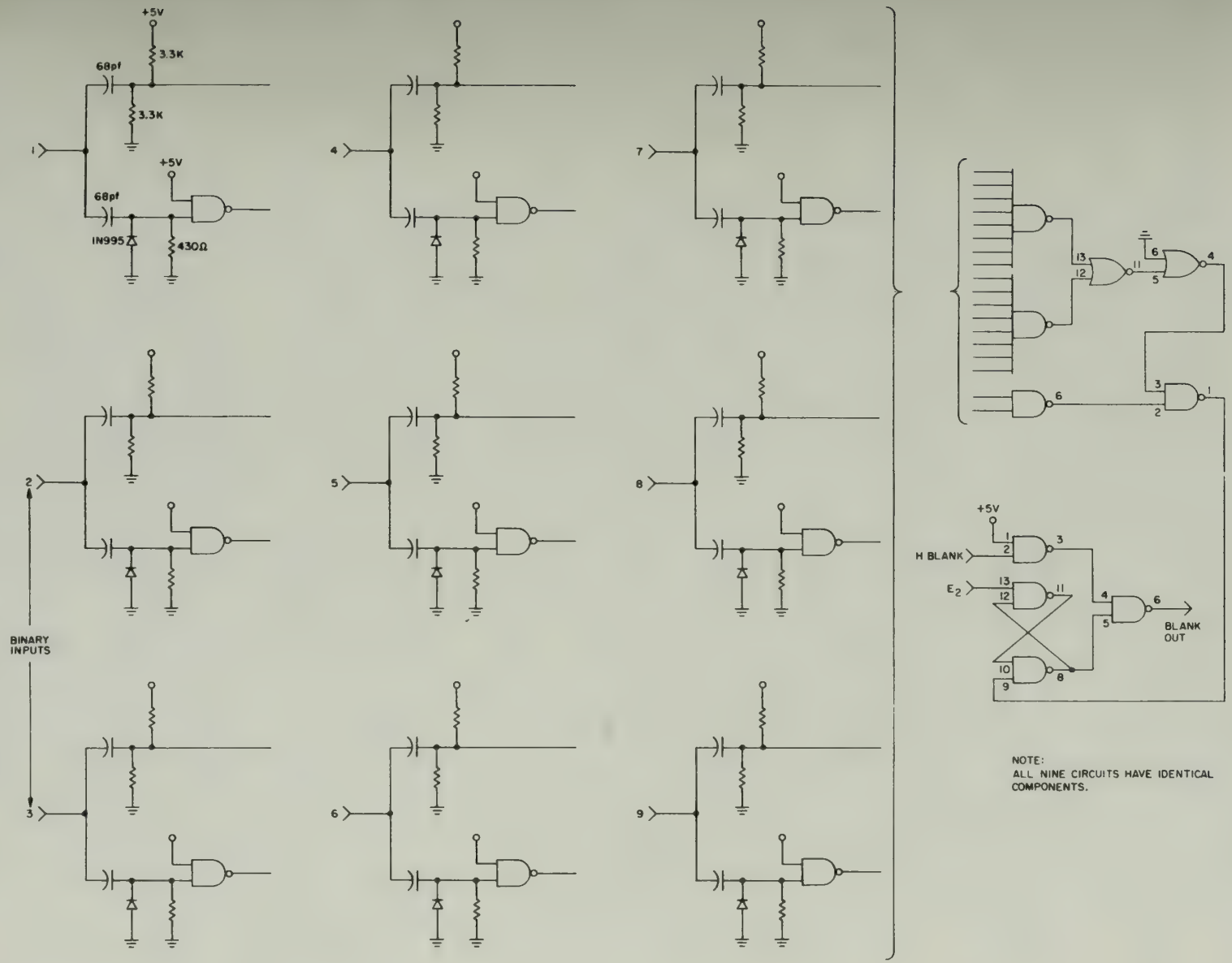


Figure 3. Vertical Deflection Failure Detector

2.3 ORBIT

2.3.1 The Horizontal Line Problem

ORBIT, formerly called Functional Encoding, stands for On-line Reduced Bandwidth Information Transmission.

The problem of satisfactorily rendering horizontal lines (co-directional with the sweep) has been described in earlier reports. A solution has been adopted and is as follows.

It will be recalled that the video signal from the transmitting camera is encoded as a monotonic "staircase" waveform, the width of each stair being constant in time and its height being proportional to the distance of the given intersection from the left hand side of the picture. The width of the video pulse to be encoded depends on the slope of the given line with respect to the sweep direction, getting wider as this slope diminishes. Pulse widths greater than some figure on the order of 200 ns are now treated as indicating the start of a horizontal line segment and are encoded into the transmitted signal as a double-width stair.

This is decoded at the receiver in such a way as to draw a continuous segment for a time corresponding to the difference in height between the double-width stair and its successor. Figure 1 shows an example of the encoding.

The system modifications have been designed and are being implemented. Further circuit details will be presented in a later report.

Peter Oberbeck

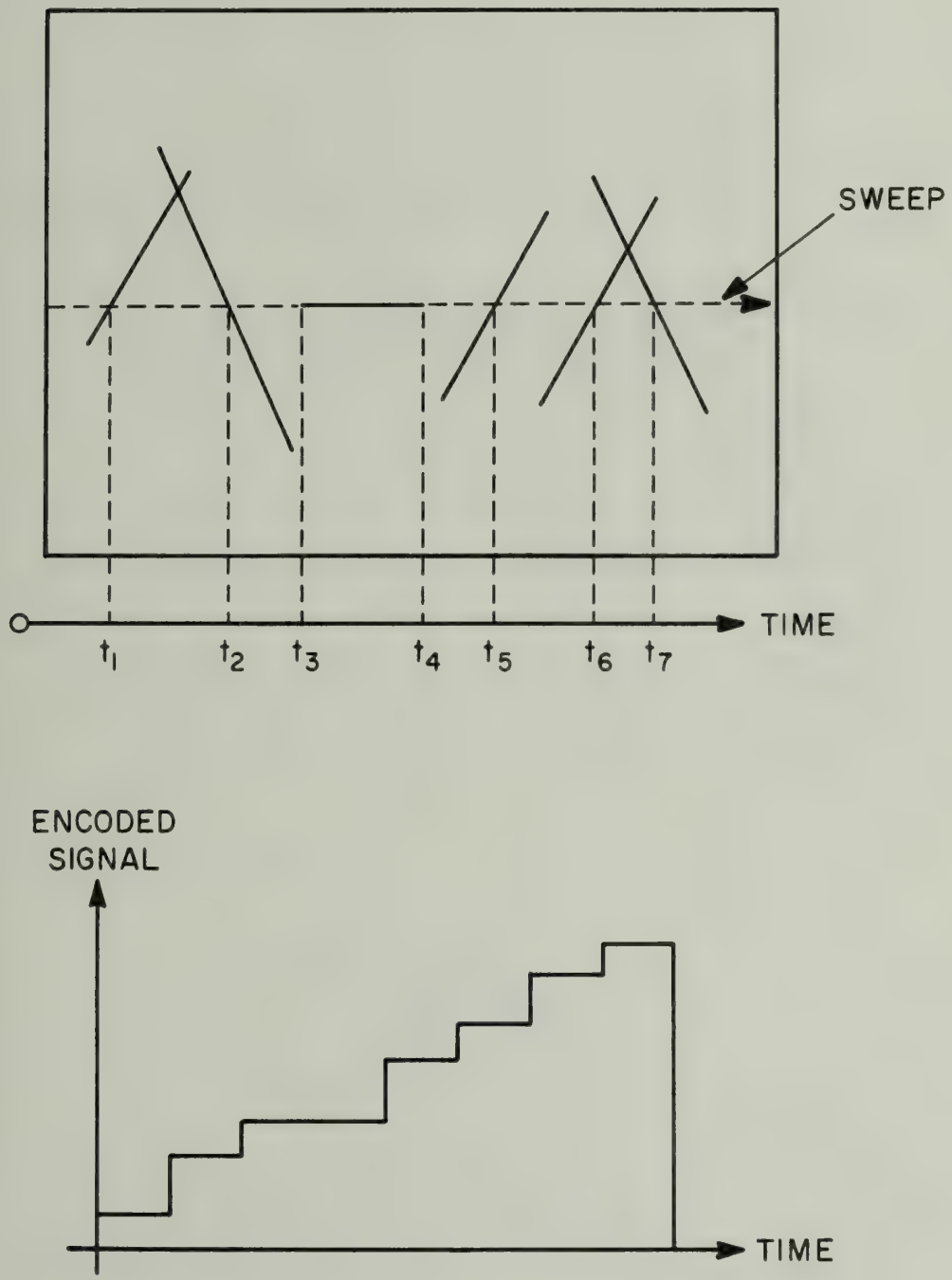


Figure 1. Single scan containing horizontal line segment (a), and encoded signal (b), showing double-width stair. Stair heights are proportional to $t_1, t_2, \ldots$, etc.

2.4 Transformatrix (Project No. 17)

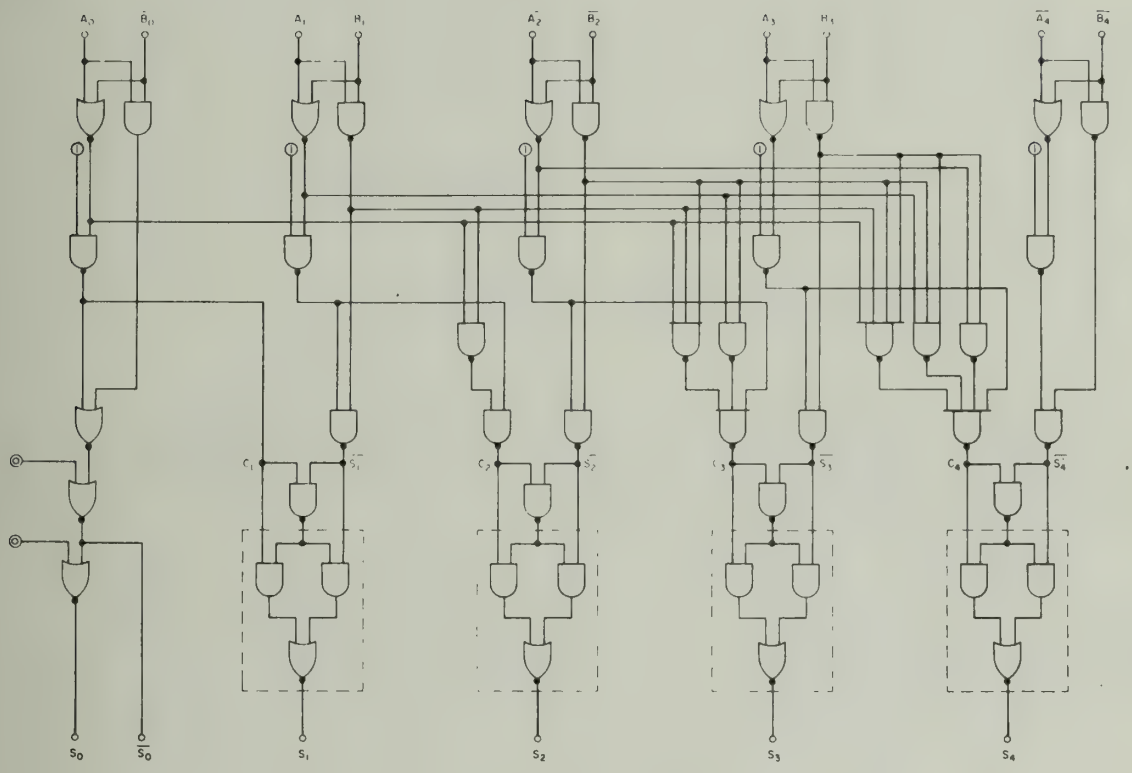
2.4.1 Five Bit Adder

The Transformatrix Processor requires 33 identical 5-bit adders. The adder was designed to meet the following specifications:

1. Maximum propagation delay (input to output) $\leq$ 30 ns.
2. Because of stringent timing requirements, the difference between the maximum and minimum propagation delays is to be kept as small as possible.
3. The inputs to the adder will be from flip-flop registers. Only the true or the false sides of the flip-flops (but not both) are to be used so as to reduce system interconnections.

The configuration of the adder is shown in Figure 1. To achieve the desired speed a look-ahead carry mode was employed. Standard speed (t_{pd} = 13 ns typical) AND'S are used in obtaining S_0 and $\overline{S}_0$ in order that the delay paths of the first two sum bits will match the delay paths of the last three sum bits. Experimental results indicate that the maximum propagation delay is 30 ns and the minimum propagation delay is 22 ns.

Lawrence Ryan



NUMBER	TYPE
5	SN74H00N - QUAD 2in NAND
1	SN74H10N - TRIPLE 3in NAND
1	SN74H20N - DUAL 4in NAND
2	SN74H51N - DUAL 2w-2in A.O.I.
2	MC3002L - QUAD 2in NOR
1	USN7408A - QUAD 2in AND

Figure 1. Five Bit Adder

2.4.2 "Model-T"

A 4 x 4 model of Transformatrix - Figure 2 - has been constructed to analyze the noise pick up problems that will be encountered in the final 32 x 32 version, and also to test whether the basic circuit design is satisfactory before large quantities of parts are ordered.

The inputs of "Model-T" are obtained from two boxes, each having a lamp, 16 photoconductors and provision for inserting a slide between the lamp and photoconductors - Figure 3. These two sets of 16 signals are converted to Clocked Analog Stochastic Noise - CASN - and multiplied pairwise giving

$$Z_{mn} = (XA_{mn}) \cdot (XB_{mn})$$

Because the picture display is presented sequentially on an oscilloscope, a multiplexing unit selects the proper m-n output location and the required Z_{mn} amplitude for that spot.

All the gating and timing for "Model-T", as well as for Transformatrix itself, is derived from a 10 MHz clock. This also produces the CASN signals directly; and a counter clock generator produces one pulse for every 325 10 MHz pulses, making the basic period per data point, 32.5 μsec. Thus 1024 output points are scanned in 33 msec, or 30 frames per second on the final machine. But, in "Model-T" we want to use the same basic timing as in the final Transformatrix. Thus we produce 16 32 μsec time periods and let the system rest for the remainder of the 33 msec.

In designing and building "Model-T" a new method of clock generation was discovered and will be published in the near future.

Orin Marvel

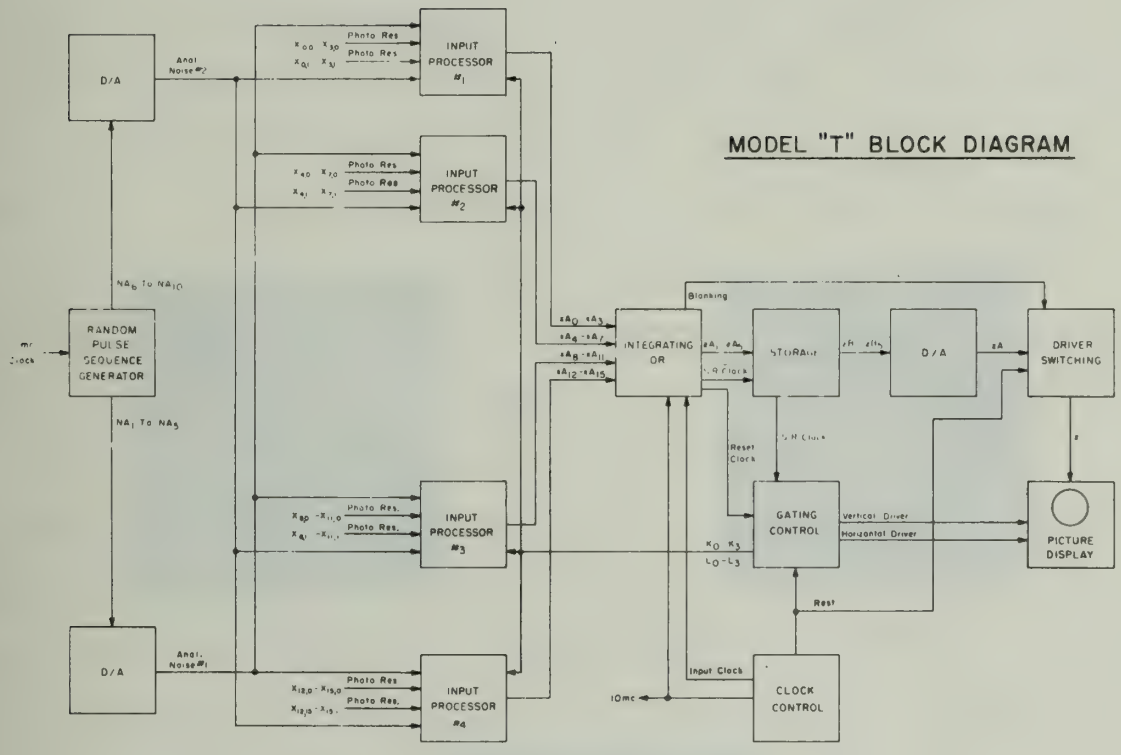
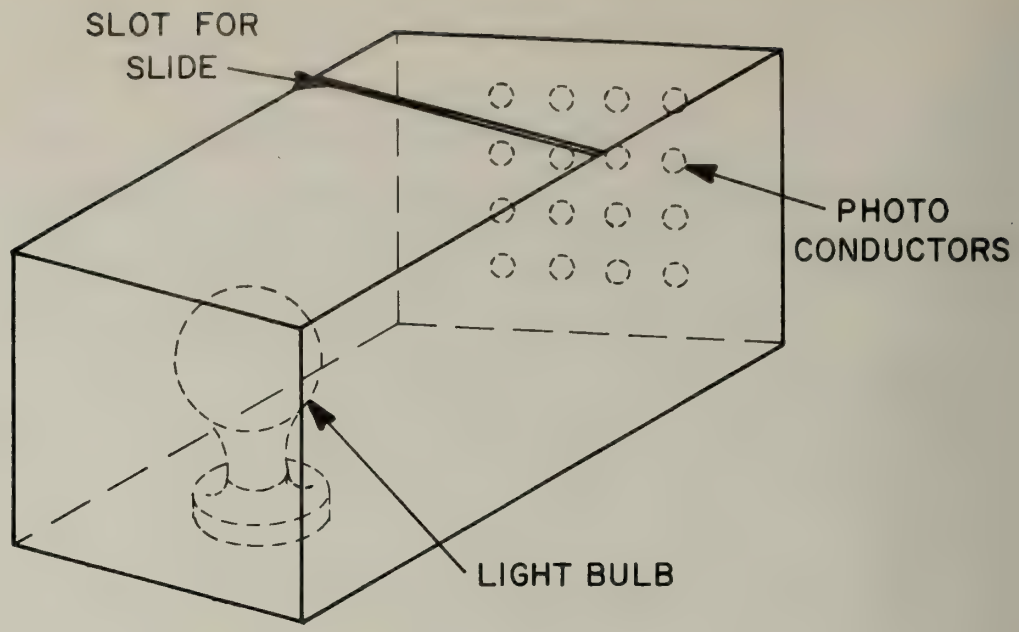
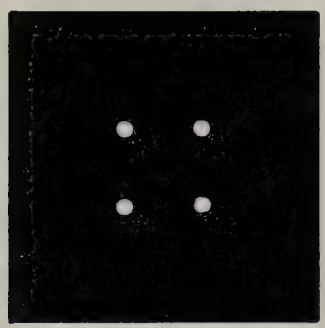


Figure 2. "Model-T" - Block Diagram



XA_{mn}

XB_{mn}



Z_{mn}

Figure 3. "Model-T" Inputs

2.5 3D Television (Project No. 19)

2.5.1 Lenticular Screen

A supplier has been found who can construct the special cathode ray tube needed for the 3D-TV scheme. This supplier can also obtain the lenticular screen which will be mounted inside the special cathode ray tube. The problem of the exact dimensions for the screen has been investigated and it has been determined that the lenticular surface of the screen will have the dimensions shown in Figure 1. There will be 256 cylindrical lenses across the surface of the screen. A one-half inch border of glass will surround the lenticular surface in order that the screen can be mounted in a frame. Thus, the overall size of the lenticular screen will be 7" by 9". The glass used has an index of refraction for yellow of 1.523. The exact value is important, as it determines the focal length of the cylindrical surface.

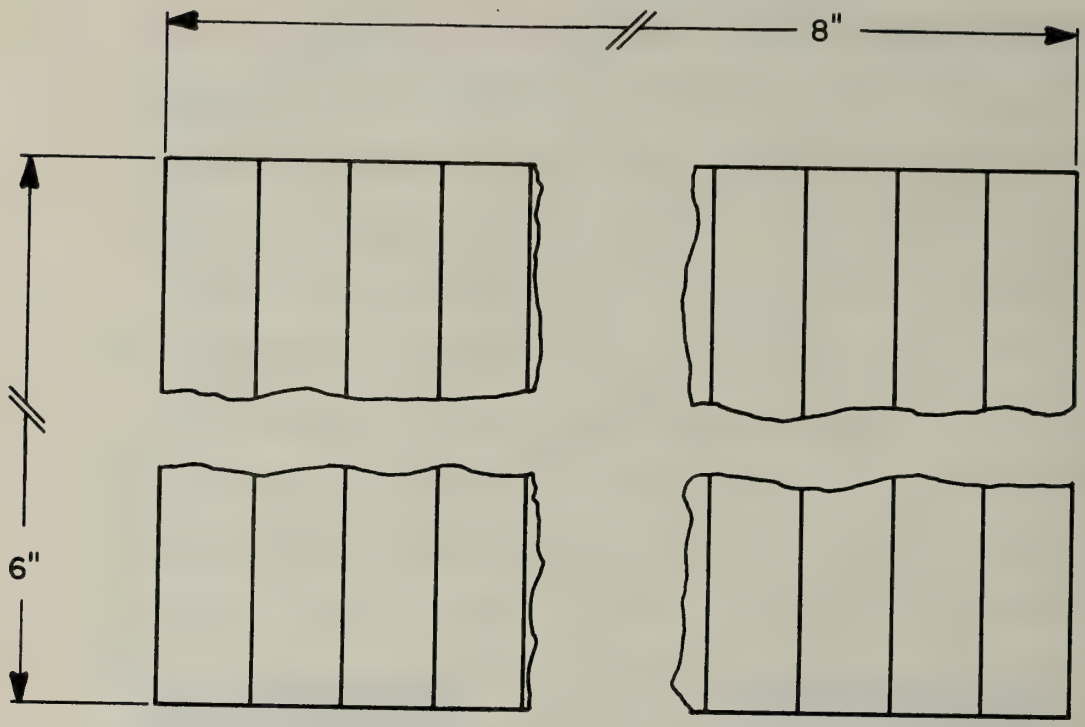
Deposited on the flat side of the lenticular screen will be a series of aluminum conducting stripes parallel to, and of the same period as the cylindrical lenses. These stripes will be 5 mils wide and placed directly beneath the cusp between each pair of cylindrical lenses.

The electronics which will drive the special cathode ray tube will be a standard monitor which will be modified to accept the tube. This item will shortly be specified.

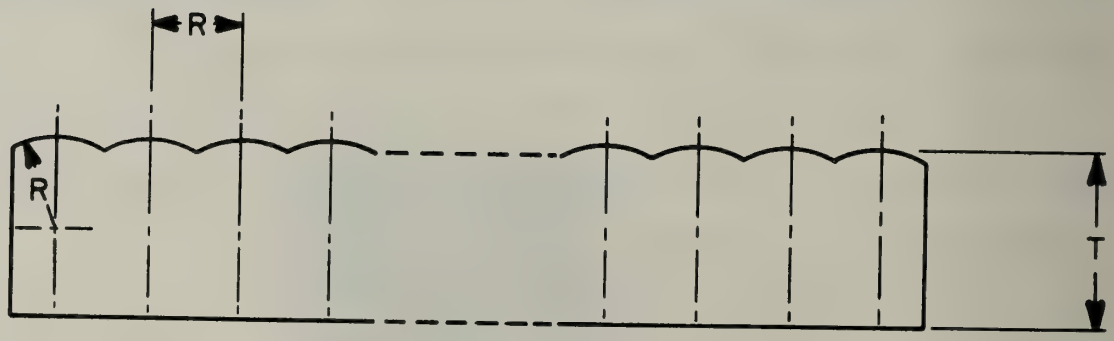
The video chopper and mixer is being investigated. A new linear integrated circuit is being considered and will be evaluated.

The quotes for the cameras have been returned and the cameras have been ordered from Cohu Electronics.

Larry Wallman



TOP VIEW



SIDE VIEW

R=0.03125 inches
T=0.09093 inches

Figure 1. Lenticular Screen

2.6 Stereomatrix (Project No. 30)

2.6.1 Introduction

The stereomatrix display system displays three dimensional figures with polarized laser beams on a screen. A point P(x,y,z) is supplied by a storage device and transformed by the stereo coordinate transformer into $P_L(x,y,z)$ and $P_R(x,y,z)$ for left and right eye viewing through polarized eyeglasses. The operator's (observer) movement is detected and computed so as to change the display correspondingly. The operator can also rotate the figure about the x, y or z-axes, as he wishes, by simply turning knobs. Due to the complexity of this project it is divided into five subsystems: (1) the coefficient computer, (2) the coordinate transformer, (3) the observer detector, (4) the cursor and (5) the display system. The block diagram is shown in Figure 1.

2.6.2 Coefficient Computer

The coefficient computer supplies the stereo coordinate transformer with the analog rotation and translation coefficients which are computed by the coefficient computer from the command signal of the operator. The computer is digital instead of the originally planned hybrid system due to the accuracy requirements and the much lower cost digital components.

Rotations will take place about the geometric center of the viewing space. The speed of the rotation is to be 12°/sec. and the increment $\Delta\theta$ is 0.2° per up-dating.

The computer performs the following computation upon demand by applying a matrix operator to the original coefficient matrix T_0 and thus obtaining a new matrix T_1:

$$T_i = R_i^k T_0 \qquad i = 0,1,2 \ldots\ldots$$

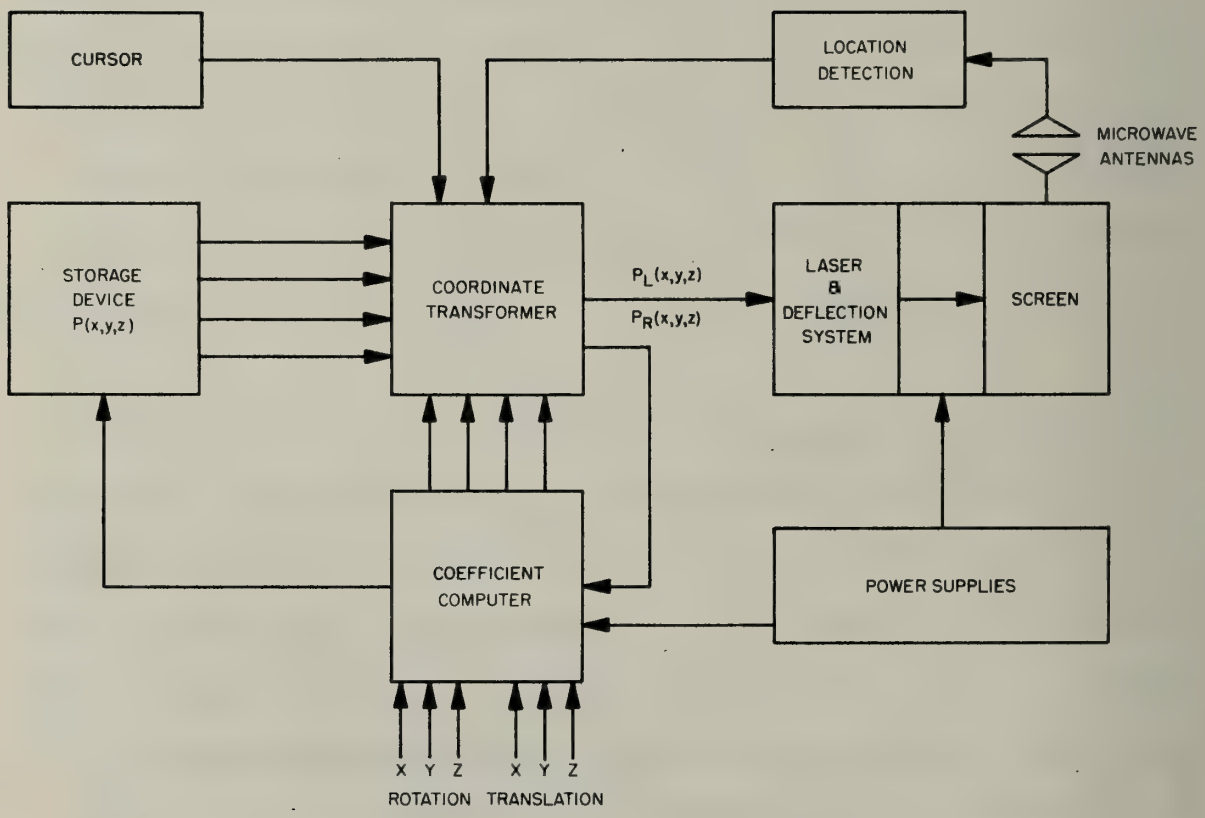


Figure 1. Stereomatrix Block Diagram

Where $T_0 = \begin{bmatrix} t_{11} & t_{12} & t_{13} & t_{14} \\ t_{21} & t_{22} & t_{23} & t_{24} \\ t_{31} & t_{32} & t_{33} & t_{34} \\ t_{41} & t_{42} & t_{43} & t_{44} \end{bmatrix}$

R_i^k is the ith rotation operator and k is the indicator for x,y or z rotation; e.g. R_i^x is the operator for rotation about the x-axis, and is defined as:

$$R_i^x = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & C & S & 0 \\ 0 & -S & C & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

where C represents $\cos(\theta_i + \Delta\theta)$,

S represents $\sin(\theta_i + \Delta\theta)$,

θ_i is the initial angle of this incremented rotation.

and

$$R_0^k = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The operators R_i^y and R_i^z are similarly defined.

The translation operator is defined as:

$$T_r = \begin{bmatrix} 1 & 0 & 0 & -X_0 \\ 0 & 1 & 0 & -Y_0 \\ 0 & 0 & 1 & -Z_0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

For example a rotation of θ degrees about the x-axis takes N

operations, where $N = \frac{\theta}{.2}$. Each operation is carried out by premultiplying the original coefficient matrix (the matrix prior to the requested rotation) by the rotational operator R_i^x:

Let $T_{i+1} = [t_{ij}"]$ be the new coefficient matrix,

$T_i = [t_{ij}']$ be the current coefficient matrix,

R_{i+1}^x be the rotational operator for the i+1 th operation,

$T_0 = [t_{ij}]$ be the coefficient matrix before the rotational operation, and T_0 remains the same throughout the total operation,

θ is the cumulative rotational angle

thus $$\theta_{i+1} = \theta_i + \Delta\theta$$

then, $$T_i = R_i^x \cdot T_0$$

and $$T_{i+1} = R_{i+1}^x \cdot T_0$$

$$= \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(\theta_i+\Delta\theta) & \sin(\theta_i+\Delta\theta) & 0 \\ 0 & -\sin(\theta_i+\Delta\theta) & \cos(\theta_i+\Delta\theta) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} t_{11} & t_{12} & t_{13} & t_{14} \\ t_{21} & t_{22} & t_{23} & t_{24} \\ t_{31} & t_{32} & t_{33} & t_{34} \\ t_{41} & t_{42} & t_{43} & t_{44} \end{bmatrix}$$

$$= \begin{bmatrix} t_{11} & t_{12} & t_{13} & t_{14} \\ Ct_{21} + St_{31} & Ct_{22} + St_{32} & Ct_{23} + St_{33} & Ct_{24} + St_{34} \\ -St_{21} + Ct_{31} & -St_{22} + Ct_{32} & -St_{23} + Ct_{33} & -St_{24} + Ct_{34} \\ t_{41} & t_{42} & t_{43} & t_{44} \end{bmatrix}$$

Thus we can see that after each operation there are eight changes in the coefficients or eight computations which implement the design of the computer. For complete rotation (n operations) about the x-axis the relation between the old and new coefficients is as follows:

$$t_{11}^n = t_{11} \qquad t_{12}^n = t_{12} \qquad t_{13}^n = t_{13} \qquad t_{14}^n = t_{14}$$

$$t_{21}^n = \cos\theta t_{21} + \sin\theta t_{31} \qquad t_{22}^n = \cos\theta t_{22} + \sin\theta t_{32} \qquad t_{23}^n = \cos\theta t_{23} + \sin\theta t_{33} \qquad t_{24}^n = \cos\theta t_{24} + \sin\theta t_{34}$$

$$t_{31}^n = \cos\theta t_{31} - \sin\theta t_{21} \qquad t_{32}^n = \cos\theta t_{32} - \sin\theta t_{22} \qquad t_{33}^n = \cos\theta t_{33} - \sin\theta t_{23} \qquad t_{34}^n = \cos\theta t_{34} - \sin\theta t_{24}$$

$$t_{41}^n = t_{41} \qquad t_{42}^n = t_{42} \qquad t_{43}^n = t_{43} \qquad t_{44}^n = t_{44}$$

Note that θ is the total angle to be rotated. By the same scheme we can determine the relations for transforming t_{ij}^n to t_{ij} for the Y and Z rotations and for translations.

The computing system is thus designed to handle the above types of computation, namely multiplication and subtraction or addition. From the operators R_i^x, R_i^y and R_i^z we can see that $t_{41} = t_{42} = t_{43} = 0$ and $t_{44} = 1$. Thus, we conclude that there are only eight computations for one increment of rotation about any one axis (if there is a rotation of 45° then 1800 computations are needed for a complete rotation) and one computation for x, y or z translation.

Since the display is to be 60 frames/second the interval of coefficient updating is 1/60 sec. or 16.66 ms. This means that computing speed is not required to be fast, so that a serial computation scheme may be used in the logic design. Also, the logic components need not be the high speed type and thus the cost is greatly reduced.

The display and transformer subsystems use analog computation methods and their accuracy will not exceed .2%. Thus, the accuracy of the coefficient computer is set at 10 bits. A 4K x 10 bit core memory with random access is designed to store sine and cosine functions for 0° to 90° in 0.2° increments. The memory is also used to store a figure for testing purposes and serves as temporary storage space during computation.

The author is investigating the available core memories and is studying the specifications vs. cost in order to find the most suitable one for this application. Also being investigated are the various types of logic components in order to determine whether RTL, DTL or TTL should be used. A logic diagram for the design is shown in Figure 2. The timing diagram is also shown to illustrate the control sequences.

Richard Cheng

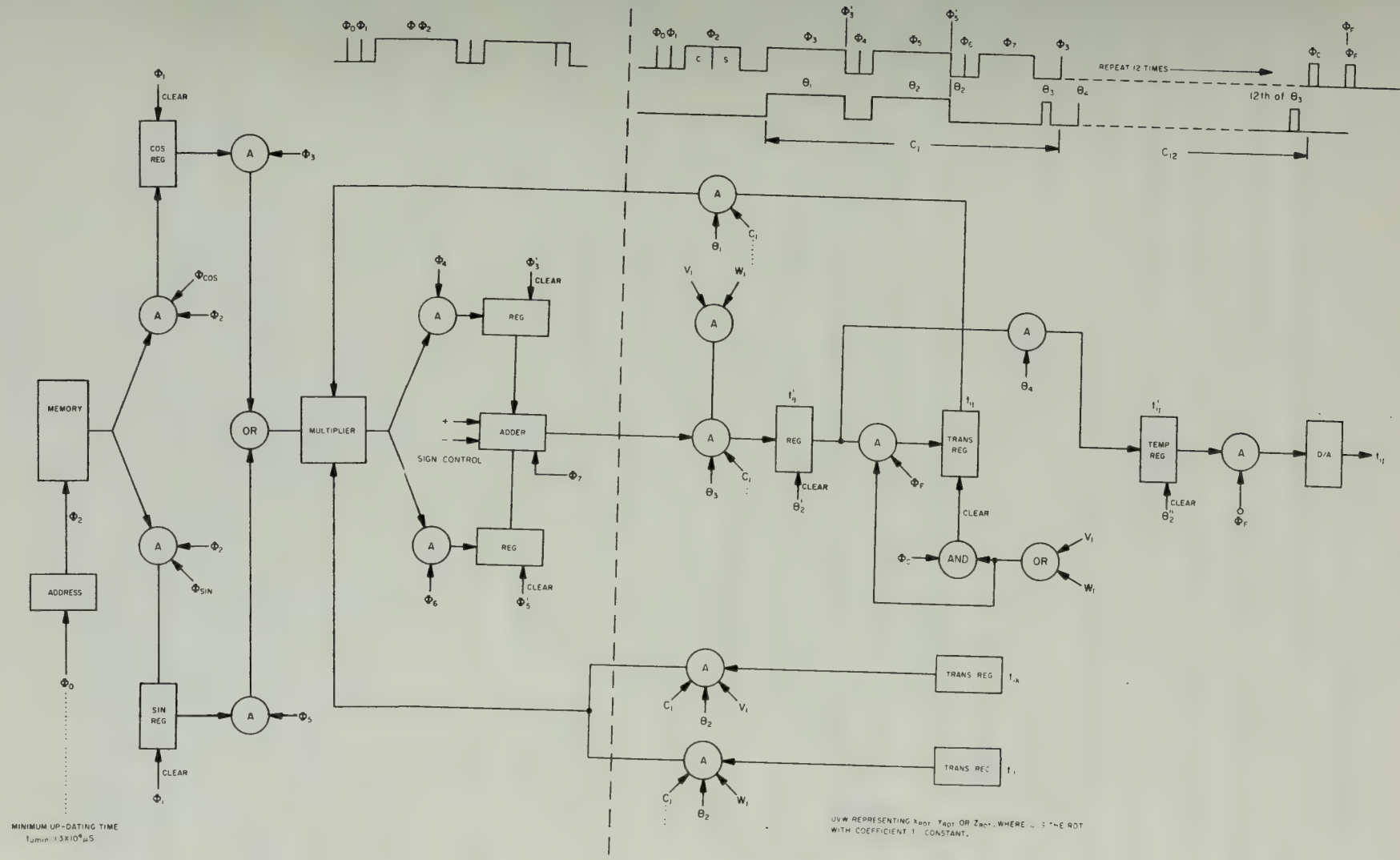


Figure 2. Logic and Timing Diagram for Transformatrix Coefficient Computer

2.6.3 Observer's Position Detector

The purpose of sensing the observer's position with respect to the Stereomatrix display is to allow him to see the sides and possibly top or bottom of the displayed object as he moves off the axis which is normal to the plane of the screen. For example, if a cube were presented on the screen, the observer might wish to see its sides by "looking around" to the right and left.

Both microwave and ultrasonic frequencies are being considered for this sensing function. The velocity of propagation of microwaves in air is too fast for the normal echo-ranging technique to be useful. The distance from observer to display will be approximately ten feet or less. This distance represents a maximum possible time delay for a reflected microwave pulse of about twenty nanoseconds (approximately one nanosecond per foot). To locate the observer by triangulation would require discerning time differences much less than the total time delay and detection of such differences exceeds the limitations of present switching devices. However, a type of microwave phase detection is being considered as a possible solution to this problem.

Ultrasonics propagate through the air with a velocity of about one millisecond per foot. With this low velocity, it should be possible to detect differences in the observer's position on the order of inches. At present, the problems related to each approach are being studied.

During the next quarter, the study of the alternative approaches will be completed and the most promising solution will be constructed in "breadboard" form for evaluation.

C. Pirnat

2.6.4 Cursor

The cursor generator produces an identifying mark, such as a small cross, which the observer may move to any position within the viewing space. When the cursor is within the neighborhood of a point on an object being viewed, an output signal is generated which indicates that the cursor and object are coincident. Various 3 dimensional controls are being investigated for their simplicity and ease of operation. The basic circuitry for the control will consist of three-2 input analog comparators, used to indicate coincidence between the cursor's x,y,z values and those from the transformer. An AND gate denotes coincidence between all three comparators. Figure 3 shows the scheme.

Terry Quarton

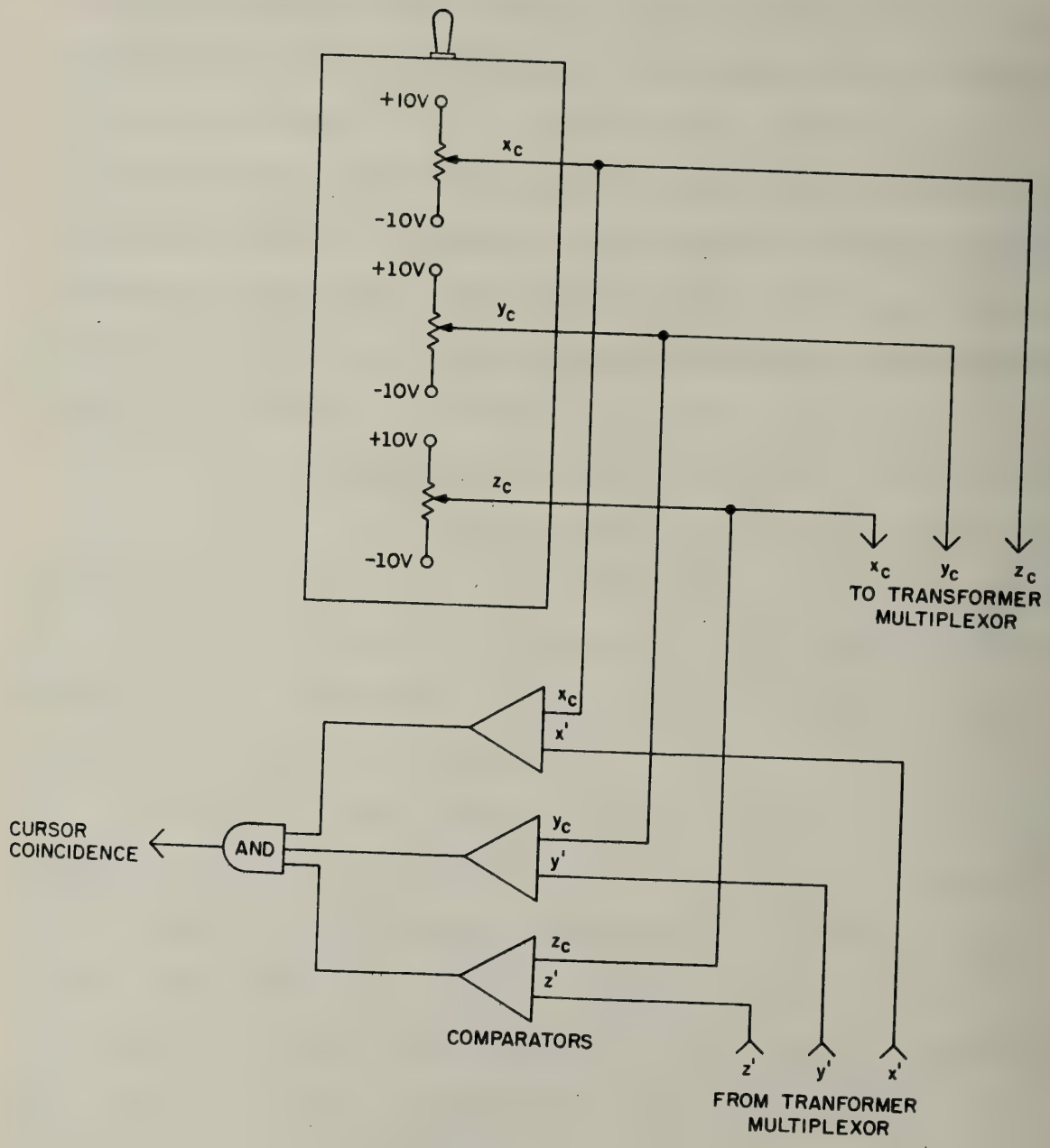


Figure 3. Cursor Generator

Form AEC–427
(6/68)
AECM 3201

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3. COMPUTER SYSTEMS RESEARCH

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Reports Written

1. Gear, C., Weidenhofer, N., Whaley, A. The University of Illinois PLORTS system--Phase 0 Provisional User's Manual, Department of Computer Science File No. 793, University of Illinois, Urbana, Illinois 61801.

Papers Presented Orally

2. Gear, C. W. Graphics in a Timesharing Environment, Conference on Computers in Nuclear Physics, Skytop, Pennsylvania, March 1969.

C. W. Gear, Principle Investigator

3.1 Ordinary Differential Equations

3.1.1 Automatic Differential Equation Solver (C. Ellis, K. Ratliff)

The ODESSY program has been copied onto tape so that other tape copies can be made if requested.

Pass I has been modified to eliminate the necessity of taking partial derivatives which are not actually used in calculations. There had been a possibility of exceeding the capacity of the Compiler with certain types of differential equations involving calls to functions.

Comments have been added to both the Supervisor program and Pass II of the O. D. E. Compiler.

An updated version of the FORTRAN part of the integration package has been produced. It contains many of the options available in the entire package, but its use is considerably different. Since it is written completely in FORTRAN, it can be used on machines other than the IBM 360.

ODESSY UPDATE: The ODESSY program has been modified to allow for graphic output. This change involves the Supervisor and the FORTRAN Integration programs.

The Supervisor now recognizes the keywords OUTPUT, OUTPUT EACH, and GRAPH. The OUTPUT keywords replace those using the word PRINT and the data associated with the new keywords applies to both printing and graphic output. The keyword GRAPH is associated with data indicating the nature of the graphs requested.

The word OUTPUT is followed by a list of variables whose values are to be output at the specified intervals. The interval is given as a number following the keyword OUTPUT EACH.

The keyword GRAPH is followed by five numbers, separated by commas, which represent the following data, respectively.

1. A one or a zero indicating that the plotting is to be done on the printer (using library subroutine, PLOTZ), or on the CalComp Plotter.

2. A number indicating a lower bound on the range of the plot variable(s).

3. An upper bound on the range of the plot.

4. A number, I, indicating that the last I variables in the OUTPUT list are to be plotted against the independent variable. $(0 < I \leq 6)$.

5. An integer which tells what multiple of the plotting interval is desired as the printing interval.

This information is placed in COMMON after processing and is then used by the Integration program to accomplish the actual plotting.

If the keyword GRAPH is used, the basic integration interval is taken to be the plotting interval. The user may specify a printing interval which is larger than the plot interval, in which case printing is suppressed at appropriate times.

When one plot interval has been traversed, the pertinent results are stored. At the end of the entire integration these results are used to plot the requested curve(s).

The User Manual has been modified to include an explanation of the graphic output feature.

Work has begun on a program to investigate techniques for the inversion of sparse matrices.

3.2 Graphics

3.2.1 DEC 338 Software (T.-Y. Lo)

The work on the implementation of the general purpose display package is proceeding with the debugging of the routines to provide the facility for a user to define his own basic elements. He can use these

elements to construct a model of his design problem at later stages in the design process. The following are descriptions of routines and mode operations that have been checked out.

1. INTERRUPT HANDLING ROUTINE. This is an overall interrupt routine to handle all the possible interrupts when this display program is running.

2. DISPLAY FILE GENERATOR. This is a routine to generate the display file of the defined basic elements and the one under construction from the source table. By adding a subroutine to handle the directed or nondirected connection lines, this routine can be used also in the stage 2 to develop the display file of the defined basic elements and their instances. The source table is used to record the display location of each basic element defined at the stage 1 and the parameters and function description associated with it. The same table is used to record the instances of basic elements and their associated text strings.

3. LINE DRAWING MODE. When the stage 1 program of this display package is initiated, a string of blinking characters 'DO YOU WISH TO SPECIFY A NEW ELEMENT?' and a nonblinking string 'YES NO' are displayed at the top of the display scope with a directed connection symbol, a nondirected connection symbol, and a connector symbol at the bottom left corner of the scope. If 'NO' is light-penned by the user, the stage 1 is concluded by saving the source table and other data into a backup storage device for later retrieval. A user can construct up to 28 elements of his own. If 'YES' is light-penned by the user, the system displays a tracking box at the center of the scope and a grid covering almost the whole scope. The user can draw any arbitrary figure on the scope incorporating lines, character strings, and other previously defined elements. He can also fix a line or nonintensify a line or draw lines vertically or horizontally.

4. CHARACTER MODE. At any time in the line drawing mode, a user can input character strings as parts of the line drawing. The teletype keyboard interrupt will cause the system to enter the character mode and the UIMON8's TEXT EDITOR is called into use. An escape from the TEXT EDITOR will cause the system to go back to the line drawing mode with the character strings displayed from the center point of the tracking box. The location of the tracking box is not changed by the character mode operation. For the timebeing, only the first line of characters is displayed and the other lines are simply ignored. Displaying of multiple lines will be implemented later.

5. SUBPICTURE MODE. This mode of operation can be enforced at any time from the line drawing mode. In this mode a user can append a previously defined element as a part of the element he is currently constructing. An escape from this mode will cause the system to go back to the line drawing mode again. The use of elements as parts of other elements is for mnemonic value only in the first stage.

3.2.2 FPL/II (S. Wilkins)

The work accomplished during this quarter has been limited to testing of the conditional primitives 'SIGN' and 'COMP' discussed in an earlier quarterly report. The basic framework of FPL/II is now completed with the exception of the communication primitives 'READ' and 'PRINT'. With the basic framework of FPL/II as it now stands, other primitive capabilities can be added to the system as flowchart input. The communication with the CRT and console has been simulated in this first design stage by using a card reader and a printer. The second stage of the implementation of FPL/II is currently in the planning stage. Now that the communication links from S/360 to the CRT and console via PDP7-PDP8 are available, the simulated communication used in the design stage will be replaced by the actual communication facilities. These facilities will allow the flowchart interpreter to receive a flowchart from the CRT and to communicate with the user via the CRT and the console.

3.2.3 360 Graphics Monitor (M. Michel)

During this quarter, implementation of the basic communications facilities, as outlined in the previous quarterly report, was completed. In addition, work was begun on the next version of the system, which will make use of a 2701 data link to replace the PDP7/630 hardware currently used to access the 360 system.

3.2.3.1 Current Status

The 360 communications, data definition, and translation macros are finished and complete documentation on their use is available. The non-terminating partition facility with interactive 360 monitor is also in operation.*

The 'UIMON8' interactive monitor for the PDP8 is completed and provides the following facilities:*

1. User routines for communication with the 360 system.
2. High speed graphics terminal for the timesharing system.
3. Graphics text editor with the ability to store text files on the 'DECTAPE' system or send them to the timesharing system, or with hardcopy output on the teletype.
4. Message switching for 360 input to allow independent functioning of various system and user routines.
5. Flexible 360 input load/go loader for automatically passing data or object code to the PDP8.

* Consult File No. 317.

3.2.3.2 Work in Progress

In preparation for the arrival of the 2701, revisions in 'UIMON8' are underway. These include rewriting the sections of code which handle remote (i.e., 360 system) input, rewriting some of the routines that communicate with the timesharing system, and writing routines to replace some of the timesharing facilities formerly provided by the PDP7. The 2701 will provide the 360/PDP8/338 configuration with a high speed data transfer capability which is essential to large, highly interactive graphics analysis systems.

During the coming June, the 360/50 will go to an MVT operating system. In this mode of operation, timesharing, graphics, ASP, and various other systems will occupy core space concurrently. In addition,

certain system linkages currently in effect will change. Hence, work is in progress to update the current 360 interactive monitor and macros for the new system, and to enable the monitor to take advantage of a region-to-region communications facility which is also being added to the 360/50 system. This facility will allow various systems, such as timesharing and graphics, to pass data to each other directly. So for example, interactive programs in the graphics region would be available to users at teletypes other than just the one on the PDP8 console.

The debugging facility for the system was respecified during this quarter, and the PDP8 end was completed. However, the implementation of the 360 end has remained in the very initial stages due to the amount of work needed on the other portions of the system.

Implementation of routines, such as a character recognizer, are underway in advance of an expected data tablet. Ways of utilizing the new tablet for existing programs are also being explored.

Routines to interface the flowchart drawing system with 'UIMON8' have been completed, but the interface to the flowchart interpreter system is still in the planning stage.

'PDP8ASM', the 360 program for assembling PDP8 source programs, is in the process of being integrated with the 360 program for assembling PDP7 programs: the resulting system will be capable of assembling either type of program under constraint of the parameters specified.

A simple linkage to allow FORTRAN and PL/I programs to communicate with the PDP8 is partially completed and will enable a larger range of users to access the graphics facilities of the PDP8/338.

3.2.4 Disk Operating System (H. Levin)

A. Disk Checkout

A comprehensive set of test programs designed to continually check all functions of the disk and printout useful error tables was written.

Subsequent running of the program indicated an unusually high error rate. Plans are now being formulated to add some type of hardware error checking scheme to the disk controller.

B. Filing System

A filing system has been defined for the Disk Operating System (DOS). A program named DOSGEN will be provided which will convert a conventional DECTAPE into a DISCTAPE. The standard bootstrap loader will then be used to load a DISCTAPE onto the disk at the beginning of a machine session. All normal operations will then be carried out without reference to the DISCTAPE. When DOSEXT is called, the updated disk contents will be restored to the DISCTAPE.

1. Nucleus of the DOS

At the heart of the DOS are seven basic routines, the first three of which are programs that are dynamically invoked by system and user programs.

a. RWDISC - used to read and write multiples of 128 words on the disk. This program provides blocking and unblocking of the large sectors on the disk.

b. and c. PTFILE and GTFILE - used to access named files and to create new ones. A prefix can be typed by the user before a file name indicating where the file is to be found (i.e., on disk, DECTAPE, paper tape, etc.). Subsequent calls will return specified portions of the previously named file. The calling program can be transparent to the type of device that the file is on.

d. UPDATE - similar to UPDATE as implemented on the DECTAPE system except that updates may be made from all banks of core.

e. DELETE - used to delete a file.

f. ESCAPE - restores most of core for execution of user programs.

g. DOSEXT - restores the disk to the DISCTAPE.

Inherent in the filing system will be the ability to invoke programs by name.

3.3 PLORTS Timesharing

Several modifications and improvements have been made to the current system. Experimentation with running timesharing with a priority greater than that of ASP has been performed.

For the projected PL1 system, Pass I which is essentially complete, is being modified to agree with certain design changes being made to the system. The overall structure of the system has been defined, and is described herein.

Work on Pass II has just been taken up in earnest, and it should be complete by the publication of the next quarterly report.

3.3.1 ASP (P. Boekhoff)

A number of bugs in the PLORTS and FILE DSP's have been formed and corrected; for example, FILE now deblocks properly. The PLORTS DSP and the corresponding code in timesharing have been modified so that the programmer's name is picked up from the /*ID card and now appears on the job receipt slip, as does a time-and-date stamp.

The problems of intertask communication in the MVT system which is due to appear in June have been defined and appear to be conceptually solved. Still to be written is an SVC routine which will allow a task to pass an arbitrary string of data to any other task. The first task will issue a command equivalent to a write; the second, a read (asynchronously of course). The SVC will keep a list of current requests. When a matching

pair has been found, the SVC will move the data from the write to the area specified by the reader, and will perform the necessary POST. This and an existing attention routine, which enables timesharing to specify an ECB to be posted when an attention interrupt is received from the PDP7 (this posting is now performed by ASP) will allow the timesharing system to function essentially as it does at present. Modifications needed for timesharing and the DSP's to change over to MVT are expected to be minimal--coding and debugging of these modifications will be performed shortly.

One of the current complaints about the timesharing system has been response time. It was proposed that moving timesharing into the high-priority partition (over ASP) of the 360/50 would result in significantly better terminal response time without seriously impacting the operation of ASP. A minor modification was made to timesharing so that it now runs indifferently in either partition. A test job stream was run through ASP in partition 1 (low priority) for two cases. First, the stream was run with only a WAITR in partition 0; thus, ASP was functioning alone. Second, timesharing was loaded into partition 0 and allowed to run at a moderate activity level while the test stream was again running through ASP. ASP was able to run the stream slightly (1.5%) faster in the second case. This was in rough agreement with an almost identical test run previously at M. I. T. Scatter in the results was avoided by the simple expedient of not repeating the run.

The proposal to run timesharing in partition 0 was vetoed for several reasons. It is believed, however, that running timesharing in physical partition 1 while making OS treat it as the high priority partition is feasible and will overcome the objections to the original scheme. This plan is currently being tested.

Several minor additions have been made to the existing PLORTS system. Probably the most significant is the time facility; the system now timestamps login messages and job receipts, and a TIME command for

the terminal user has been added to the system (response to this command is of the form 21:45:09 THU 4/24/69).

3.3.2 Pass I (J. Christopher)

The first set of modifications to Pass I to incorporate the new branching conventions have been made. These changes include moving the symbol table from the storage section to the "user" section, and moving all those locations which are used in both Pass I and II to the front of the storage section. The "user" section now contains all buffers for outputs from Pass I, and the dynamic storage for expression calls.

The constant analysis routine has been extensively modified. It now has two phases. Phase I has existed and been debugged for quite sometime. Phase II was originally a debugging aid, now it actually converts constants from EBCDIC characters into internal representations, using the routines CHRFIX, CHRFLT, CHRBIT, BITFLT and CHRFIX. Some modifications are still necessary however. The correct symbol table pointer is output in the output buffer, indexed by R7.

It has been decided to not make any symbol table entry at all for operators since the pointer to the symbol table is unique. Hence, the location of the symbol table for operators are actually part of an output buffer.

A number of conceptual changes have been made to Pass I. It has been decided not to have a permanent secondary output buffer (POLISHZ). The output stream from Pass I will be contiguous for each statement, and each statement will be written out as a line of a PLORTS file.

No symbol table entries will be made in Pass I. All symbol table entries will be made in Pass II. Pass I puts out constants directly in the output stream, the first byte being the constant flag, the byte preceding the constant itself being the length. The format has not yet been completely specified, but there will be flags to indicate the constant type.

As a consequence, output for those statements which cause secondary output will be placed first in a temporary buffer, and then the secondary output will be combined with it and the result output into the output buffer.

3.3.3 Pass II, Pass III (A. Whaley)

A. PL1 System--Overall Structure

There are three main objectives of the PL1 timesharing system which is being constructed; these are:

1. To allow interactive program debugging and execution.
2. To allow a macro command facility.
3. To allow use of the system as a desk calculator for easily performing short mathematical computations.

Naturally, it is desirable to have all of these functions integrated into a single, outwardly consistent package. The first point is satisfied by the construction of a conversational, interpretive PL1 system. A description of how this system is modified to implement the second and third objective follows.

When the user is first connected to the system, he is in communication with Pass I of the PL1 compiler. At this point, there are two things that may be typed in. Both are PL1 statements legal within the subset being implemented, the difference lying in the presence or the absence of a preceding line number. As it happens, the rules concerning what is a legal PL1 statement vary slightly between these two cases, as will be discussed later. The input statement is analyzed syntactically to see if it is a legal statement. It is not considered for legality in conjunction with any other statements. All error messages are printed at this time. If there are any fatal errors, Pass I then returns to the user for more input.

Barring fatal errors, and if the line has a line number preceding it, the compiler (Pass I) proceeds to enter this line into a source program file. Its position in this file is determined by its line number. In addition, a broken down version of the statement is entered into a scratch file (created by the compiler) with the same line number. (See Figure 1) Pass I then returns to the user for additional input.

In the event that there were no errors in the input line, and it contained no line number, it is immediately executed. (See Figure 2) The output from Pass I is placed into an in-core buffer specially reserved for this purpose. Pass II is then invoked to compile this single statement into interpretable polish postfix. Pass III is then invoked to execute the statement. If and when control ever passes beyond this single statement, Pass III returns control to Pass I, which returns to the user as always for additional input. If the single statement was an assignment statement, a special switch in Pass III is set, causing printing of the result of the assignment statement before control is returned to Pass I.

It may be noted at this point that the third objective has been met. With the above arrangement, however, it may now be unclear as to how the first objective is to be met, let alone the second. Referring to Figure 4, it is seen that all unlinenumbered lines are part of an outermost block. In a batch environment, this block would correspond to the operating system as its only function is to serve as a desk calculator and to invoke other programs. As may also be seen in Figure 4, the source program being maintained by Pass I (referred to as the "active" file) is similar to any other file in the system except in two ways. To the user it is the easiest to modify, since all lines with line numbers which are entered (when the user is connected to Pass I) go into this file. To the compiler, it is the easiest program to execute, as the intermediate object information has already been generated by Pass I.

Invoking any program in the system is quite simple: the user simply types a CALL statement with no line number. The activity which then ensues is illustrated in Figure 3. If the program has previously been invoked, then the executable polish code already exists, and the program reference is easily resolved by Pass III.

Otherwise, an attempt is made to find the program in each of the following sources:

1. active source file.
2. user library of source files.
3. system library subroutines.

At this point, the method of implementing the first and third objectives has been demonstrated. An explanation of the difference in the rules of syntax for statements with line numbers and those without will serve to point out the method of implementing the second objective. When a statement with no line number fails to be identified in Pass I, it is examined for legality as a CALL statement which is missing the CALL keyword and the outer parentheses around the parameter list. This allows the user to write a program in PL1 which may be used as a command processor of his own. It also allows almost all of the system commands to be PL1 programs in the system subroutine library. They are invoked by an input statement with the name of the program followed by the list of arguments to be fed to it.

3.3.4 RJE and Filing System (N. Weidenhofer)

A. Phase 0

The timesharing system has been on the air and available to a small number of "guinea pig" users for some time. It has grown quite popular and we currently have applications for more terminals than we have the hardware to handle. Besides the seven direct coupled terminals within D. C. L., we have five telephone lines connected to the PDP7 multiplexor.

On this basis we have accepted applications from users on twelve separate dial-up terminals. Although the basic hardware--the PDP7 and the 360/50--is designed to handle many more than the twelve ports accounted for above, we still lack ports for the DEC 630 which is the interface between the PDP7 and the incoming lines.

The system has settled down to an average of about one crash every two or three days. Aside from bugs which have been corrected, these crashes stem from the following causes:

1. Conflicting simultaneous operations on files. The system was originally designed to allow any number of users to simultaneously access a file with no bad effects. This plan had to be compromised somewhat, however, by keeping disk printers in core in file control blocks. Simultaneous reading and writing is still safe; but if one user destroys a file which is being accessed by another user, the second user's pointers suddenly become invalid which usually results in a crash. In particular, about 90% of the system crashes during the past quarter have been caused by a file being destroyed while ASP was writing into it.

2. Invalid pointers within the file structure. When the system crashes unexpectedly, there is no opportunity to write all buffers in core onto the disk. For this reason, when timesharing crashes (or ASP which takes timesharing down with it) disk pointers may exist in catalog or directory blocks which are not valid. When the files containing these invalid pointers are later referenced, a system crash may result. This problem has been reduced by immediately writing out critical blocks, but more work remains to be done and the problem still accounts for the majority of the 10% of the crashes not mentioned above.

3. Improperly de-allocated blocks. When a disk block which had been in use is no longer needed, it is put on a linked list of such blocks for reuse. Through a bug which has not yet been found, an invalid device address sometimes creeps into this list so that when the system

Figure 1

Action When Line-Numbered Line is Typed In

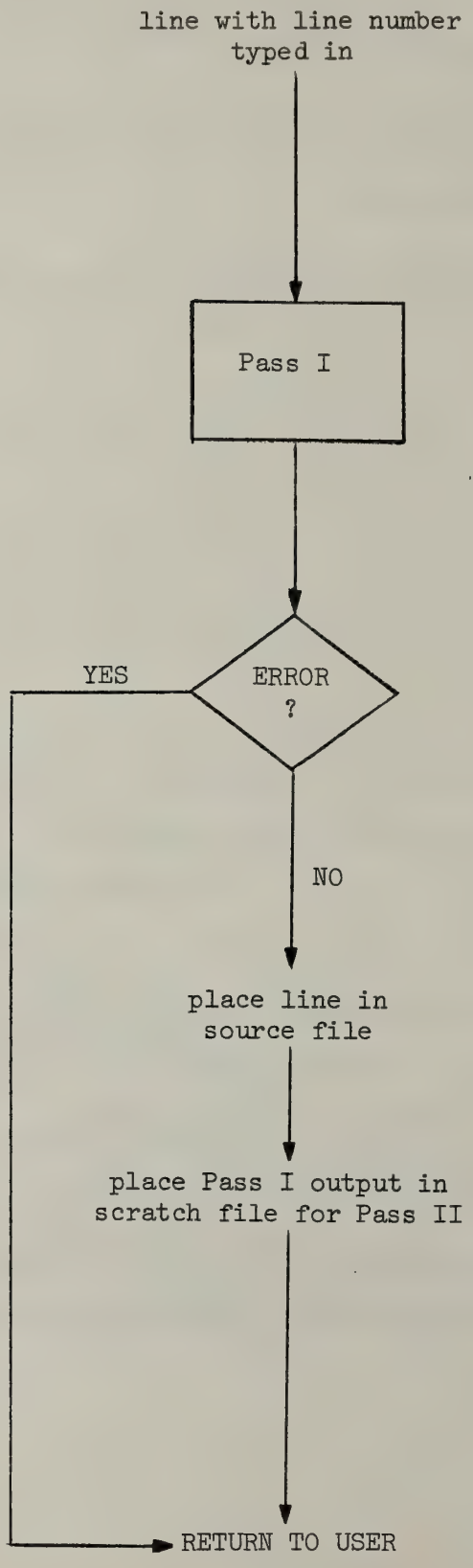


Figure 2

Action When Line with no Line Number is Typed In

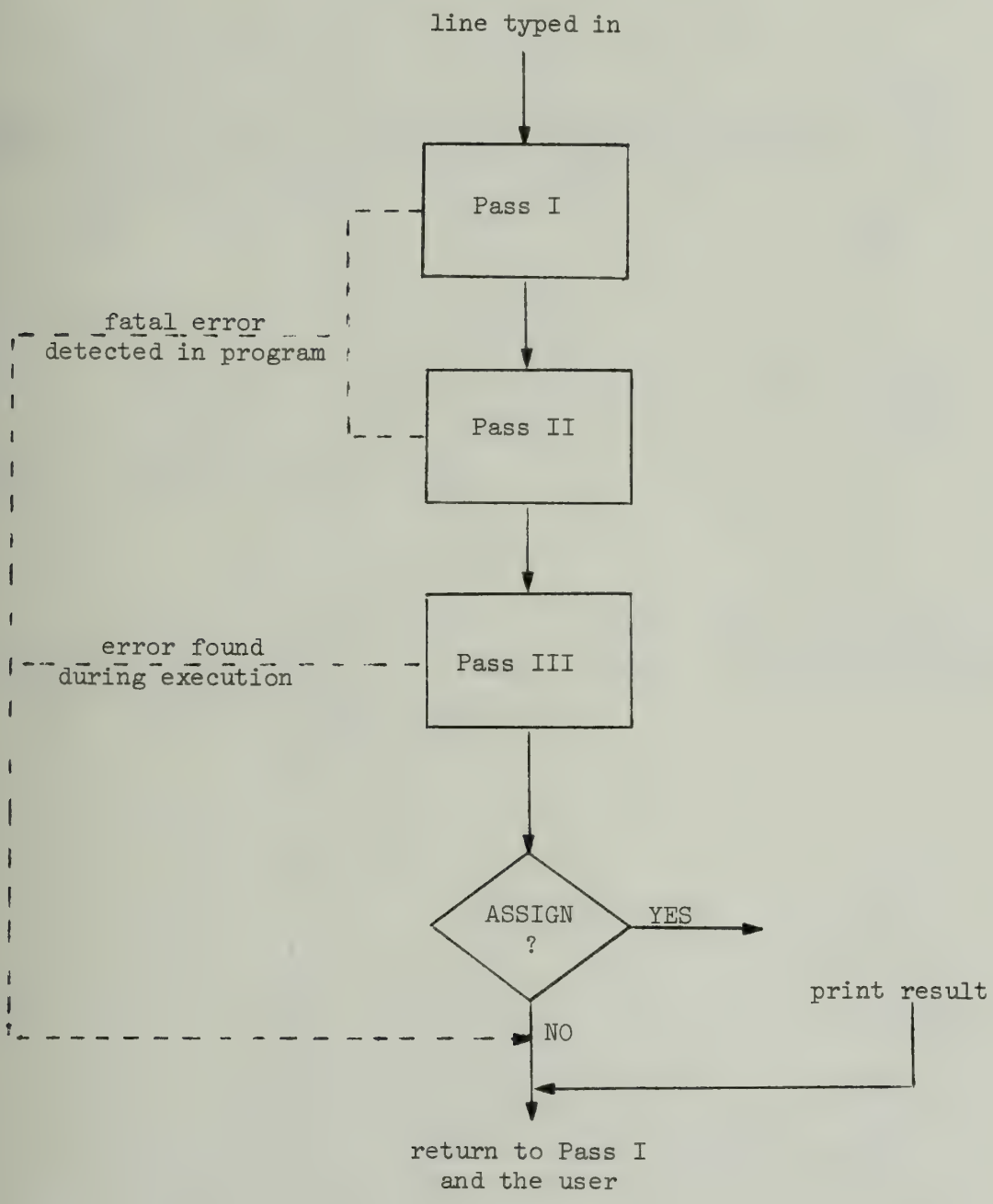


Figure 3

Resolving an Unknown Subroutine Reference in Pass III

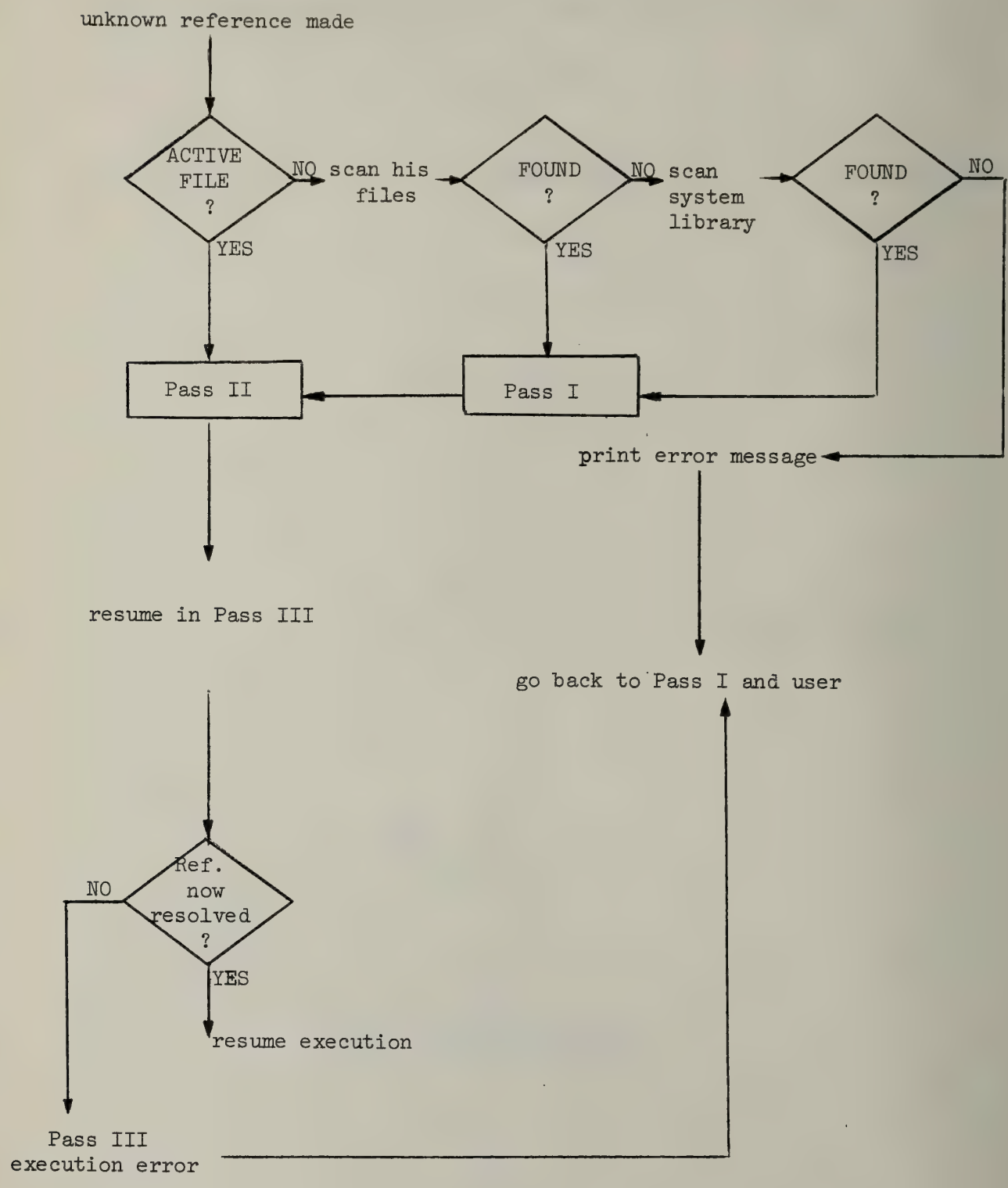
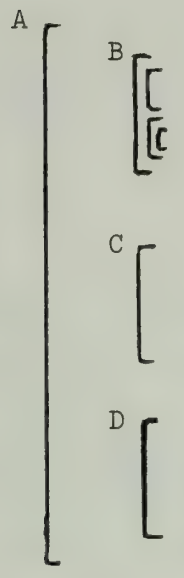


Figure 4

Program Block Structure



Block A is the outermost block, and contains all immediately executable statements and all invoked programs. Blocks B, C, and D are programs which have been invoked.

attempts to use one of these blocks a crash results. This has happened twice in the past quarter and could only be fixed by dumping the contents of the disk onto tape and restoring it.

The tape dump and load programs mentioned in the last quarterly have been debugged and the disk is dumped onto tape daily. Except for the two times mentioned above, a reload has never been necessary although it has been done several times in debugging the dump and load programs.

3.4 Computer Design

3.4.1 Microprogram Optimization (L. Greninger)

As a result of a search for a general framework for working with and modifying microprograms, a control/data flow graph model was settled upon. To facilitate working with program structure in this form, work was begun on a graph processing system, GRSYS. During this quarter the GRSYS graph manipulation system was brought up to a point where, as a pure graph processor, it is a working system. Capabilities for interpreting the specification of a subgraph recognition and manipulation template and for executing the process described by such a template were added to GRSYS and have been debugged. Assuming one is willing to input a program's data flow graph node by node and branch by branch, the program's structure can be manipulated by GRSYS according to the templates input along with the data flow graph. Optimization of a simple sort has been successfully performed, and language translations are being looked at.

The current work is toward the derivation of a program's control and data flow graphs from source language input. A highly formatted input form for source languages has been devised, suitable for inputting low-level assembler and microprogramming languages. The system will now accept this input form and automatically generate a control flow graph for the program from it. Once the control flow graph is built, template matching will be used to derive a modified/combined control-and-data flow graph for the program.

A description of the system is also being written concurrently with this programming work. The two efforts are definitely interactive in nature.

3.4.2 Display Processing Unit (R. Hostovsky)

The instruction set of the Display Processing Unit (DPU) is compatible with DEC 338. The DPU will execute the Control State instructions in the same way as would the DEC 338. The execution of Data State orders will result in generating an incremental code.

The increment code is a group of four bits which tells the beam which direction to move (one of eight) on the screen. The display file, no matter in which mode it has to be displayed, will be converted to increment representation; stored first in the DPU core and then moved to the disk. The display on the screen will be performed by reading the information directly from the disk. The coordinates of X and Y in "point mode" will be stored on the disk. The same is true about intensity and scale information.

Interrupt handling will be somewhat different from DEC 338.

Edge violation will be detected upon generation of the increments and an interrupt will be issued. When the picture exceeds the bounds of the scope face but not causing an edge violation, the X and Y coordinates within the DPU are updated without storing the increment code in the core. The transfer will continue when the calculated beam position is inside the screen boundaries.

Light pen and push button interrupts will occur only later when the actual display is performed. As a result, the execution of the instruction RDAC (6061) will be different from DEC 338. In order to restore the "display address counter", the beam position has to be compared with the original display file (in the PDP8 core) at interrupt time.

Two additional IOT instructions are required; one to address the CRT, and the other to identify a CRT causing an interrupt.

The detailed logical design of the communication section between the DPU, the AMPEX core, and the DATA DISK is in the final stage of development.

3.5 Numerical Analysis Library Development (L. Fosdick)

During this quarter the quasi-interactive linear algebra system underwent further development. Additions were made to allow it to compute eigenvalues and eigenvectors of symmetric and non-symmetric matrices. Also, further checking features were added to the system.

A routine to allow arithmetic operations of arbitrarily (almost) high precision to be executed in a FORTRAN program was put into operation. This was adopted from a version prepared by H. Thatber at Notre Dame written in CDC FORTRAN. It will be used to develop high precision test results for checking library subroutines.

Timing of our library subroutines and the inclusion of this information in the short form subroutine descriptions was completed in this quarter. Storage allocation information was also put into the descriptions at this time.

A routine for solving two point boundary value problems according to an algorithm of Wachspress was completed in this quarter. Other algorithms for this class of problems are under study.

An existing program for making text corrections to the master tape file in our Library Information System was completed in this period. A new KWIC index is about to be run.

3.6 Computer Maintenance and Construction (C. Carter, H. Lopeman, R. Miller)

The interface from the PDP8 to ILLIAC III has been tested and is cabled in and running. Satisfactory results are being obtained.

The disk has been returned and the clock track written. At the factory, the additional 32 tracks were wired and the logic put in for a total of 64 tracks. Very elaborate tests are now underway to establish reliability.

An automatic RIM loader was designed and built for the PDP8. Push button RIM loading is now possible. A tape bootstrap loader is under consideration for the PDP8 also.

Preliminary investigation of a PDP8-338 link to an IBM 2701 PDA has been completed. This would allow the 338 to speak directly to the 360 system.

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4. ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III

(Supported by Contract AT(11-1)-1018 with the U.S. Atomic Energy Commission)

Illiac III is an experimental computer being designed and constructed by the Department of Computer Science as a first instrument to explore the potentialities of high speed image processing. Besides providing normal computational facilities, the machine includes a parallel processor for visual data processing (the Pattern Articulation Unit) and an extensive complement of visual input/output equipment.

4.1 Outline of Illiac III Programming Developments

The section numbers of the outline below correspond to section headings of this Progress Report.

4.2 Operating System

- 4.2.1 Image Processing Package (IP^2)
- 4.2.2 Telecommunication Processing Package (TP^2)
- 4.2.3 Multiprocessing and Interrupt Handling
- 4.2.4 Software Support of Hardware Design

4.3 Translators

4.4 Graph Transformation Grammars

4.5 Game Model of Image Processing

4.2 Operating System

4.2.1 Image Processing Package (IP^2)

File Number 788 was issued this quarter containing a brief survey of image processing/description languages and a preliminary syntax for a new image processing language, ICON.

This work has led to questions concerning the formal descriptive capability and semantic interpretation of the language as well as the procedural model in which the language will be used. Current work on these complex questions is centered on the formulation of an initial model (see Section 4.5).

John C. Schwebel

4.2.2 Telecommunication Processing Package (TP^2)

A manual of both software and hardware aspects of the Data Concentrator for low speed terminal devices is still in preparation, but should be available by the end of next quarter.

L. A. Dunn

4.2.3 Multiprocessing and Interrupt Handling

The interrupt system, from the point of view of the Taxicrinic Processor, has been clarified and a detailed explanation has been circulated in a preliminary manuscript form.

4.2.4 Software Support of Hardware Design

A companion program to the wiring listing program POOL (S. P. Krabbe) has been designed and implemented. With this program, CESS, one obtains a cross referenced listing of all wires, giving the beginning and terminal connection. The program makes extensive use of list processing techniques in order to conserve storage, since the connection matrix is very sparse. It is thus hoped that no intermediate peripheral storage will be needed, with the result that the program will be nearly I/Ø bound.

Preliminary documentation is finished and debugging nearly so.

R. M. Lansford

4.3 Translators

All work on translators has been stopped momentarily as all Research Assistants previously working in this area have been drafted for the war in Viet Nam.

4.4 Graph Transformation Grammars

Our previous work with the classification of binary relations has been done to provide a basis for studying grammars that permit the relational transformations appropriate for image processing. Studies have involved:

a) Logical properties of binary relations.
b) Operation or relation-preserving properties of binary relations.
c) Reversible or information-lossless transformations.

Items a) and b) were discussed in File Numbers 762 and 769 issued this quarter.

We have now discovered some new operation-preserving properties to expand the previous set. Work is continuing to determine if this set is complete in the sense that precedence and reversibility of graph transformations may be inferred directly from the properties of relations without regard to the relation name. The expanded set of operation-preserving properties offers some hope that this hypothesis will prove correct at least for a subset of possible graph transformations.

4.5 Game Model of Image Processing

In formulating an image processing model in which image recognition procedures can be clearly expressed, it became obvious that a general cognitive model was required.

The initial model we are studying allows structured descriptions, attributes, and recognition on the basis of partial information. Some necessary parts of the model are:

Object Space

Name Space

Attribute Space

Mappings or Relations between these spaces

The present formulation is aimed at achieving a simple model which will consistently describe a number of image processing procedures.

J. C. Schwebel

4.6 Outline of Illiac III Computer System

The section numbers of the outline below correspond to section haedings of this Progress Report.

4.7 Central System

- 4.7.1 Taxicrinic Processors
- 4.7.2 Fast Core Storage Modules
- 4.7.3 Arithmetic Units
- 4.7.4 Interrupt Unit
- 4.7.5 Pattern Articulation Unit
- 4.7.6 Exchange Net
- 4.7.7 Status of the Main Frame Assembly

4.8 I/O System

- 4.8.1 I/O Processors
- 4.8.2 Channel Interface Units
- 4.8.3 Device Controller Communication

4.9 Peripheral System

- 4.9.1 Secondary Storage System
- 4.9.2 Scan/Display System
  - 4.9.2.1 Scanner-Monitor-Video Control
  - 4.9.2.2 Prototype Scanner
- 4.9.3 Intermachine Link to DEC PDP-8/338 Display
- 4.9.4 Low Speed Terminal Network

4.10 Power Distribution

- 4.10.1 Primary DC Power Supplies
- 4.10.2 Power Distribution System
- 4.10.3 Control of Power Distribution Systems
- 4.10.4 A.C. Power Distribution System

4.11 Unassigned Equipment Pool

4.12 Documentation

- 4.12.1 Engineering Manual
- 4.12.2 Circuit Books
- 4.12.3 Logic Book
- 4.12.4 Wiring Tables
- 4.12.5 Opto/Mech. Design

4.13 Circuit Research and Development

4.7.1 Taxicrinic Processors

Documentation

Work on the TP manual is continuing. The description of the interrupt system as it affects the various control sub-sequences has been completed. Volume I of the TP Manual, which contains descriptions of the basic register and logic hardware in the TP, is currently being edited and a version for final release should be ready shortly.

The signal name listing has continued to grow as more control logic is designed.

About 50 new logic drawings have been generated. As of the present time these are only preliminary drawings, as interaction between design modules will undoubtedly require some modification.

Logical Design

The TP interrupt system has been logically integrated into the total TP design, and all flow chart modifications have been made. Work on the Interrupt sequence itself is continuing.

Using the basic control point strategy described in previous Quarterly Progress Reports, the work on the Main Control Sequence has been begun. This includes the basic instruction decoding, and the preliminary operations necessary before the actual instruction sequence can begin.

B. J. Nordmann

4.7.2 Fast Core Modules

During this quarter the design of response logic was completed for the fast core modules. This logic has been installed in one of the core memories and partially checked out using a simulator. Additional printed circuit boards (two for each core) have been ordered from Fabri-Tek Inc. to implement the logic. This logic is responsible for a) acquiring an information path, via the Exchange Net, back to a requesting processor, and b) supervising the transfer of information from core back to a requesting processor.

S. Paul Krabbe

4.7.3 Arithmetic Units

4.7.3.1 Logical Design

During the last quarter a preliminary document concerning the transformation of control flowcharts into logic was completed and distributed for comment to the engineering staff. Actual control logic design for the arithmetic units has continued and is nearly 50% complete.

4.7.3.2 Hardware and Wiring

The wiring tables for the 475 cards (per A.U.) of the processing hardware were verified with the logic drawings. The back panel wiring for the processing hardware is now in progress. Approximately 12,500 wires are required.

D. E. Atkins

4.7.4 Interrupt Unit

No additional work was done on the design of the Interrupt Unit due to commitments of higher priority.

4.7.5 Pattern Articulation Unit

4.7.5.1 Logical Design

The primary work in this area has been concerned with the problems associated with the driver tree structure necessary to drive the Iterative Array. A board has been tentatively designed which would allow the standard 1018-268 cable driver to drive a set of local drivers in Sections 1 and 3. This system is preferred since it then requires only 11 cables per section to drive all the stalactite drivers. This board will be sent to the layout group shortly.

Due to the nature of some of the PAU instructions a more promising approach to the PAU control structure has been examined. This approach uses a set of pseudo-asynchronous subroutines which may call each other or use a small microprogrammed store to set control byte information. Details will appear in the next report.

4.7.5.2 Documentation

Work in this area has been primarily putting out Report No. 314 on the PAX Programming system. Work is continuing on the second BOOLE report and on an overview of the stalactite/driver interconnection problem.

4.7.5.3 Hardware and Wiring

Power has finally been applied to Section 3 of the Iterative Array. Thirty two stalactite cards and associated drivers have been successfully powered up and some preliminary checks made. The noise on power busses has been quite tolerable, even better than expected.

The next task is to determine whether the current driver wiring will have to be replaced by coax.

The Transfer Memory core stack has been mounted in Section 2. This was done to allow the possibility of fixing the door of Section 4 in case the amount of cabling to this door is such that it should not or cannot be moved.

The TM power wiring is currently being completed and once finished checkout may commence.

The display system has been reinstalled in the main frame and awaits only the 1018-285 boards for complete checkout. The boards have been etched and are currently being fabricated.

R. T. Borovec

4.7.6 Exchange Net

This quarter the logical and power wiring for the Exchange Net (Sections 13 and 14) was completed. These two sections are now installed in the Illiac III mainframe. The checkout of these two sections will be started as soon as DC power becomes available.

4.7.7 Status of the Main Frame Assembly

The following list of items describe mainframe progress during this quarter.

1) Installation of the false floor for DCL 223 that overlaps the existing false floor in DCL 280 was completed. The completion of this floor a) permits the routing of interconnecting cables between the Illiac III mainframe (in DCL 223) and the remainder of the system, and b) provides a path from the cold air outlets, under the floor in DCL 280, to equipment in DCL 223 and DCL 217.

2) Installation of primary AC power outlets inside the Illiac III mainframe was completed. Fans and utility outlets will be connected to the primary outlets. Provision has been made to a) earth ground the Illiac III mainframe structure, and b) isolate the mainframe structure from DC ground.

3) The status of DC power distribution associated with mainframe only is listed as follows.

   a) All modine regulator to capacitor bank connections have been completed between Sections 75, 76, 77, 78 and 70. Section 70 (capacitor bank) services Sections 1, 2, 3 and 4.

   b) All capacitor bank to buss (load) connections have been completed between sections 1, 3 and 70.

4) A prototype fan assembly was designed and installed in section 5. This fan assembly will guarantee the CFM required to cool a mainframe "wing", i.e. sections 1, 3, 5, 6, 7, 8, 9, 10, 11, or 12.

5) Robert C. Amendola is working up a design for removable wing covers.

6) Spaces between all printed circuit board connectors are being sealed to eliminate air leaks. Sections 1, 2, 3, 4, 13 and 14 are completed.

7) John Fileccia is working up a design for an effective seal between the mainframe and the removable false floor panels that surround it.

8) Co-axial cables are being assembled that will connect the Exchange Net to the principal modules both inside and outside the mainframe.

9) Burndy receptacles are being installed under the false floor at the bottom of each wing. These receptacles will accept the co-axial cable that will ultimately connect a particular wing to the Exchange Net. Twisted pair transmission line will be used between the receptacle and the wings.

10) All power wiring for the Arithmetic Unit (Section 7) minus control, has been completed.

S. Paul Krabbe

4.8 I/O System

4.8.1 I/O Processors

Request Service Unit

A major subassembly of the I/O Processor handles the communication with the I/O channels, and specifically regulates the information exchange with the Channel Interface Units. This subassembly, the Request Service Unit, reflects all the nuances of channel transmission and therefore its design is highly sensitive to control features of the Channel Interface Units and the remote Device Controllers. These latter designs are now largely frozen. Accordingly detailed flowcharts of Request Service Unit operation were prepared this quarter and are now undergoing detailed consistency checking.

IØP Command Structure

In the course of design considerable simplification of the command structure and interrupt handling of the IØP has been noted. Revised documentation on the IØP operation will be available next quarter.

B. H. McCormick

4.8.2 Channel Interface Units

Initial streamlining and correction of CIU flowcharts has been completed. Logic diagramming is 90% complete. Card layout is about 40% complete.

Communication with IØP and Device Control groups is excellent and has already pointed out several irregularities which were almost anomalies.

Current efforts are directed towards further streamlining and simplifications with an eye to reduction of hardware and time for data and control processes.

J. V. Wenta

4.8.3 Device Controller Communication

The communication path between the device controllers and the CIU's has undergone intense review, bearing in mind that the control sequences for these interface signals must be compatible for both Illiac III's Channel Interface Units and for the standard IBM System/360 channels. In this light the Channel Interface Unit's control flowcharts are presently being closely examined for possible inconsistencies.

The structure of the device controller communication unit has been defined and the control sequences for this structure are currently being refined.

V. G. Tareski

4.9 Peripheral System

4.9.1 Secondary Storage System

No progress made during this quarter.

4.9.2 Scan/Display System

4.9.2.1 Scanner-Monitor-Video Control

The layout and wiring lists for the scanner counters, registers, input/output buffers, equality and theta function have been completed and the wiring of the drawers for these sections has been initiated. The design or realization of the controller by control point implementation is now processing.

Report No. 308 entitled, "Parametric Description of a Scan-Display System" was issued on February 5, 1969. This report was accepted for presentation at the Spring Joint Computer Conference 1969.

File No. 794, "Programmed Aids for the Scan-Display System of Illiac III" was issued on March 14, 1969.

R. G. Martin

4.9.2.2 Prototype Scanner

Development in this area has been quiescent pending installation of a new system of collection optics.

J. L. Divilbiss

4.9.3 Intermachine Link to DEC PDP-8/338

The interface hardware to the PDP-8 has been completely checked out and installed in its permanent cabinet.

Work in the software area is currently going in two directions. First a set of general programs is being created to facilitate use of the interface.

Secondly, the PDP-8/360 link (via the PDP-7) is being explored. It is anticipated that this link will be used, for example, to run a portion of a simulator on the 360 and create a file in the PDP-8 which corresponds to the output signals. The same input file would then be applied to the Illiac III hardware and the hardware responses compared to the simulator outputs. With the advent of a non-terminating partition in the 360 this procedure could be accomplished in real-time thus accelerating the Illiac III checkout.

R. T. Borovec

4.9.4 Low Speed Terminal Network

During this quarter an evaluation of the control logic associated with the low speed terminal network (LSTN) was started. This evaluation will guarantee that a) all of the requirements imposed by the devices serviced by LSTN will be satisfied, and b) interface requirements between the LSTN and the Illiac III system will be satisfied.

4.10 Power Distribution

4.10.1 Primary D.C. Power Supplies

While performing initial checkout of the power distribution system for the PAU wing (Section 3) several power supplies became inoperative. It is evident that further testing be performed on the fire damaged power supplies to obtain assurance of reliable operation when the mainframe is turned on in the future.

4.10.2 Power Distribution System

The application of all power to Section 3 of the mainframe was completed this last quarter. The connection of modine channels, capacitors, buss bars and associated cables for (1) IA wing (Section 1) and (2) TM wings (Section 2 and 4) has been initiated.

4.10.3 Control of Power Distribution System

The control of the power distribution for Section 3 was tested and functioned properly. The wiring lists for the remaining control sections for the mainframe are now being generated and should be complete by the next quarter.

4.10.4 A.C. Power Distribution System

A.C. power receptacles for each wing in the mainframe were wired under the false floor in Room 223 this past quarter.

4.11 Unassigned Equipment Pool

No changes were made this quarter.

4.12 Documentation

4.12.1 Engineering Manual

A copy of a report compiled by D. E. Atkins pertaining to the specification and design of control point type logic was added to the engineering manual.

R. G. Martin

4.12.2 Circuit Documentation

Thirteen new circuits or versions of circuits were documented during this quarter. Three engineering changes to existing circuits were completed.

4.12.3 Logic Documentation

No change in EU, CIU, AU, IØP, Logic Documentation, Scanner-Monitor logic is now in intermediate drafting stage. PDP-8 logic is approximately 90% completed.

J. Otten

4.12.4 Wiring Tables

This quarter the following wiring lists were made using POOL I

Subsection	Section #	No. of Wires	Comments
Iterative Array (Display)	1,3	1,567	Second Revision
Logic and Power Wiring for the Arithmetic Unit	7	12,553	
EU Counter Board for the Arithmetic Unit	7	230	

S. P. Krabbe

4.12.5 Opto/Mechanical Design

From January 1, 1969 through March 31, 1969 twenty-four (24) new detail, assembly and layout drawings have been made. Seven (7) additional drawings have been processed according to engineering change orders.

Two (2) work orders have been placed with our machine shop and one (1) work order placed with the Physics Machine Shop.

S. Zundo

4.13 Circuit Research and Development

This quarter saw the completion of the following printed circuit designs.

1018-311-00 1018-316-00	These two card types permit "cord-wood" style multi-section LC filters to be interchanged easily.
1018-312-00	Provides eight bits of digitally specified attenuation for a bipolar analog signal.
1018-313-00	A simple analog to digital converter using parallel comparators.
1018-314-00	Eight control points and associated models using integrated circuits.
1018-315-00	Photomultiplier amplifier.

J. L. Divilbiss

4.14 Bibliography

During the past quarter the following reports and file numbers were issued:

Reports

308 Dunn, Lawrence A. et.al., "Parametric Description of a Scan-Display System", February 5, 1969.

314 Borovec, Richard T., "The PAX II Picture Processing System at the University of Illinois Programming Manual", March 18, 1969.

File Nos.

788 Schwebel, John C., "Toward the Specification of a New Image Processing Language", February 6, 1969.

790 Krabbe, S. Paul, "A Discussion of Illiac III Processor-Unit Communication Via the Exchange Net, March 4, 1969.

794 Dunn, L.A., et.al., "Programmed Aids for the Scan-Display System of Illiac III (to use with Report No. 308), March 14, 1969.

550-123 Krabbe, S.P., "Specifications for the Mechanical Termination of Twisted Pair Transmission Line Z_o = 95 Ohms $\pm$ 5 ohms With Burndy Contacts in the Illiac III Exchange "Net", January 28, 1969.

550-124 Krabbe, S.P., "Specifications for Power Wiring of Section 7 (Arithmetic Unit) of Illiac III Computer System", February 5, 1969.

550-125 Krabbe, S.P., "Specifications for Termi-Point Wiring of Section 7 (Arithmetic Unit) of Illiac III Computer System", February 18, 1969.

550-126 Borovec, R.T., "Specifications for Wire-Wrap Wiring of Integrated Circuit Board 1018-299-00", March 13, 1969.

550-127 Krabbe, S.P., "Specifications for Mechanical Termination of Coaxial Cables (RG-195/U Used in the Illiac III System", March 11, 1969.

4.15 Illiac III Staff[1]

Senior Staff

Dr. James L. Divilbiss - Principal Research Engineer
Dr. Robert M. Lansford - Research Associate
Professor Bruce H. McCormick - Principal Investigator
Professor Sylvian R. Ray
Professor K. C. Smith - Consultant

Professional Staff

Robert C. Amendola
Richard T. Borovec
Lawrence A. Dunn
Mrs. Linda M. Katoh
Ronald G. Martin

Electronic Engineering Assistants

David L. Foster
S. Paul Krabbe
Edmund Pelg
Frank P. Serio
Joseph V. Wenta

Electronic Technician II

John L. Fileccia
Robert G. Thomson

Electronic Technician I

Eugene E. Althaus
George T. Lewis
William A. Miller
Bennie D. Williamson

Engineers

*Daniel E. Atkins
*Sergio Franco
*Lakshmi N. Goyal
*Richard P. Harms
*Bernard J. Nordmann
*Val G. Tareski

Programmer

*John C. Schwebel

Drafting

John Otten
Stanislavs Zundo

Secretarial

Mrs. Donna J. Stutz

---

1. Not including hourly employees
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5. ILLIAC IV

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REPORT SUMMARY

Introduction

Several major problem areas were reported during the last quarter. A detailed report on the problems and the solutions was presented at the ILLIAC IV Advisory Committee Meeting in Washington, D.C. on February 26, 1969. As a result of the progress made and the solution to the problems encountered by ILLIAC IV, the Advisory Committee recommended unanimously that the Project continue to completion and gave their approval of the proposed solutions. The following are the major problem areas.

Semiconductor Devices

ILLIAC IV is being implemented with the TI (Texas Instruments) ECL dual-in-lines (DIL's). The PE has been redesigned to eliminate the MSI devices and the redesign is completed. The mechanical configuration for the PE now resembles the breadboard built by TI for Burroughs. The PE boards are approximately 3 1/2" x 4 1/2" and contain up to 20 DIL's. Artwork masters for printed circuit board manufacturing are expected to be completed in the next quarter. The Control Unit required no major change in design, with the exception that the clock had to be increased from 40 nsec to 50 nsec.

Memories Systems

Burroughs is in the process of signing a contract with Fairchild to provide memories for the ILLIAC IV PE's. These memories will be semiconductor memories with 188 nsec cycle time. Burroughs should receive the first memories in December, 1969.

Impact on Cost, Schedule, and Performance

ILLIAC IV's performance is essentially the same with the DIL technology as was proposed with the MSI devices. The table below indicates the original performance and the projected performance:

Effect of Change of Semiconductor Implementation Technique and Clock Rate

	Original Target	Present Outlook
Additions/Second	10^9 per Second	$\frac{PU's}{250} \times 10^9$ per Second
Multiply Time	400 Nanoseconds	450 Nanoseconds
Memory Cycle Time	250 Nanoseconds	200-250 Nanoseconds
Disk File Transfer Rate	10^9 Bits per Second	10^9 Bits per Second
Percent Time PE Busy	> 91%	> 91%

The projected cost to complete for a one (1) quadrant system is in the order of $26,000,000. The present schedule cost for installation of the system is September, 1970. Due to the increase in cost on the ILLIAC IV project, it has been decided to install a one (1) quadrant system at the University rather than a four (4) quadrant system.

Project Review

The University has reached an agreement with Burroughs to review project status on a monthly basis. Personnel from the University of Illinois will visit Burroughs each month and review progress and budgets on a task-by-task basis. The result of these reviews will be incorporated into the monthly status report produced by Burroughs. These reviews should provide the University with the information necessary to determine if Burroughs is meeting the schedule and cost objectives presented to the Advisory Committee.

5.1 Simulation and Debugging of PE Logic

5.1.1 PE Logic Simulator

The PE logic simulator has been modified so that it can accept up to 47 independent test cases at the same time and simulate them in parallel. The previous format of the input file is still valid. If the number, n, of operands is less than 47, the simulator prints out n sets of specified contents. An estimated execution time per clock per operand is in the order of .1 second.

5.1.2 Equation Generator Program

Due to some errors in input data to the PE equation generator program, this program had to be run again on the corrected input data of the control logic. Because the program execution took a long time, the programming has been improved.

A program for simplifying Boolean equations for the PE control logic has been written for the convenience of logical designers and diagnosticians. This program has the capability to simplify equations using DeMorgan's Law and a few other propositions of Boolean algebra.

5.1.3 Debugging of the PE Design

The simulator has been used extensively during this period in debugging the logic design. The third approach mentioned in the last Progress Report has been used in preparing test routines and approximately 200 errors have been found and corrected. The implementation of most of the arithmetic instructions with variants has been corrected. In the next quarter the use of the simulator will be mainly for verification, rather than correction, of design.

5.2 PE Diagnostics Generation

5.2.1 Assembled Code Translator (ACT)

The Assembled Code Translator program is in the process of being expanded to provide output data in a parallel form to the PE simulator. The revision involves searching a file created by ACT to determine the number of clocks in the instruction that the simulator is to execute. The F-signals for each clock in the instruction and the data associated with each clock for up to 47 executions of the instruction are then written on the output file. If the instruction is to be executed for more than 47 sets of data, it is necessary to repeat the F-signals with the additional data since the PE simulator can handle a maximum of 47 inputs. At the present time ACT II, the revised version of ACT, is being debugged.

5.2.2 Combinational Tests

Generation of new test patterns for combinational logic has been delayed until the next period because of the urgency of other tasks.

5.2.3 Path Tests

The path test development is in its final step. The main task of this quarter was the completion of the path test program. The insertion of initialization microsequences was done. The set of path tests and ordering sequences are fed into a program called TOP/FORM which produces a file called TOP/PEXIN containing the ordered sequence path tests. The TOP/PEXIN will be fed into the PE Exerciser Test Assembly Program which will produce an object code of the path test program and a fault dictionary.

The path test generator program (including the expected response calculator program) was maintained and revised during this period. A short routine for checking the clearing function of the main registers has been written and attached to the top of the path test program.

5.2.4 Control Logic Tests

An effort of generating test cases for the PE control logic has been initiated in this period. Some discussions have been concentrated on the automatic generation of the test cases. A translation from the logic equations of the PE control logic to the inputs to the PGM (Path Generating Method) program is being investigated for possible implementation in the next period.

5.3 CU Logic Simulator System

5.3.1 General

The majority of the programs comprising the CU Card Board Logic Simulator System have been coded, and debugging of the program is proceeding. A number of deficiencies (e.g., missing wiring, spurious records) in the netlists provided by Burroughs for experimental and debugging use have been discovered and corrected versions have been promised. It should be possible to generate and test a complete simulator by the time these corrections are received.

Work has progressed slowly on the CU Section Logic Simulator System, primarily due to a lack of programming manpower.

5.3.2 CU Card Simulator Generator

The initial version of the CU Card Simulator Generator system was written this quarter in accordance with the specifications developed during the previous quarter. The simulator generator system consists of seven subprograms which perform the following tasks:

1) netlist reformatting and updating,
2) signal name sort and simulation variable identifier assignment,
3) pin sort and directed graph generation,
4) initial level assignment,
5) loop detection,
6) final level assignment, and
7) simulator body generation.

Although the algorithms used in this system are almost identical to those used in the PE logic simulator generator, the programs have been rewritten to provide system refinements and increased efficiency. The major features are listed below.

1) Since there are about one hundred CU cards, a processing history is automatically generated for every set of files produced by any program. Further, file identifiers are automatically assigned to include the board name and a program run number.

2) The entire simulator generation process is oriented towards producing an efficient simulator capable of simulating many test cases in parallel.

3) Simulator efficiency is increased by using in-line logic equation coding, rather than procedure calls as in the PE simulator.

4) A netlist updating facility has been provided. Minor changes to the netlist may easily be incorporated by preparing update cards and rerunning the simulator generator system.

Typical execution times on the B5500 for the complete CU card simulator generation process are:

	TOFUND (850 records)	TIFUNA (1350 records)
1) UPDATE	45 sec	1 min 15 sec
2) WEDTR 1*	2 min 50 sec	4 min
3) WEDTR 2	40 sec	1 min
4) LEVELER	30 sec	1 min
5) REDUCE	4 sec	2 sec
6) HSEKEEP	3 sec	5 sec
7) SIMGEN	30 sec	40 sec
Totals	5 min 22 sec	8 min 2 sec

*This program currently uses a relatively inefficient linked-list bubble sort. It will soon be modified to use the highly efficient ALGOL SORT verb; anticipated running times are on the order of those for WEDTR 2.

5.3.3 CU Card Simulator

The card simulator "head" and "tail" have been completed and debugged. These are sections of code which are identical to each simulator. They contain such things as declarations, loop control, and a quite large simulator initialization and input control block. Preliminary tests indicate that the chosen format for simulator input is very efficient, resulting in low programmatic overhead for simulator input-output.

5.3.4 Simulation Results Display Program

Rather than printing simulation results as they are generated, the simulator merely dumps the values of all simulation variables at each step to an output file for subsequent postprocessing by a results display program. This permits the simulator to operate at maximum speed by eliminating the necessity for it to stand essentially idle while time consuming I/O bound results' printouts take place. The values of the simulation variables, in a user-specified format, are printed by the separate results display program.

The coding for this program has been completed during the quarter, and debugging is almost complete. Initial design predictions have been borne out entirely. Through the use of ALGOL stream (character handling) procedures, a very small, fast program has been produced which runs almost totally in the shadow time of the necessary I/O transfers.

The simulator user may (through the TESLA or PEXTAP languages) specify printing of any subset of the simulation variables in any desired order. Printouts may be in octal or binary representation. Expected results may also be presented for display and comparison to the actual results, and printout may be suppressed in cases where these match.

5.3.5 TESLA

A complete BNF syntax of the new simulation test control language, TESLA, was developed during the quarter. This was transferred

to punched cards and used as input to the ILLIAC IV Translator Writing System. After a few trivial modifications to compensate for some vagaries in the BNF to Floyd Production Language translation algorithm, a parser for TESLA was successfully produced.

Semantic action calls were added at appropriate points in the syntax; the semantic structure of the language was coded; and semantic action routine specifications were developed. Coding for all but the most difficult (and least useful) semantics have been completed and are currently being debugged.

The ILLIAC IV Translator Writing System has been the keystone in the rapid generation of the TESLA compiler. The necessity for several man-months of labor for development of a scanner, parser, and symbol-table building routines was obviated by TWS. Minor difficulties were experienced because of a current lack of documentation and instructions for generating a compiler using TWS and the relative inefficiency of the translation programs, but these may be ascribed to the yet developmental nature of the system and will undoubtedly be ultimately corrected.

A translator for generating simulator and results display input files from simple symbolic representations of the actual simulator input was also written. This has been used to provide dummy programs for simulator debugging while the TESLA compiler is being written.

5.3.6 CU Section Logic Simulator System

Because of a shortage of programming manpower, maximum effort has been devoted to the completion of the CU Card Logic Simulator System, and efficiency and program behavior in a multiprogramming computer environment. Radically different concepts such as a partially or even fully interpretive simulator are being examined, and it is even possible that two entirely different (but compatible) architectures will be selected, one for the daytime (multiprogramming) environment and the other for nighttime (exclusive-use-of-machine) environment.

5.4 CU Diagnostics Generation

5.4.1 CU Board Test Generator

The organization of the CU Board Test Generator System has been investigated during this period. The system will be composed of Failure Mode Collector, Failure Mode Selector, Pattern Generator, Bad Board Simulator, Good Board Simulator, and Test Generation Controller.

Failure modes of chips on the board are collected by the FM collector and organized in a set of failure modes of the board. The patterns are generated assuming a grouping of input signals to the board. The test generation controller requests a failure mode and a bit pattern from the pattern generator. The failure mode is put into the bad board simulator and its response is compared with that of a good board simulator (free of failure). If there is no possible detection, the controller looks for another pattern; if these patterns are exhausted, it requests another failure mode until completing the set in the case of a detection. The pattern and failure modes are recorded to produce a set of tests.

All the programs will be written in the next period except the simulators that will be created by the CU Board Simulator Generator.

5.4.2 CU On-Line Diagnostics

Because of the termination of the Self-Diagnostic Generation (SDAS) effort at Burroughs, Paoli, some of the tasks for CU on-line diagnostics were transferred to the University in this period.

The identification of programs required for on-line diagnostics has been started. An extensive effort in this area is expected in the next period.

5.5 Design Automation

The Post-Processor Program was written and returned to Burroughs. Some additions and modifications were necessary due to some

small changes in the wiring rules. As the program is used in the production phase, the identification will continue of places where additions to the post-processor will relieve manual checking and will smooth the design flow for Control Unit's PC Boards.

The University has assumed the responsibility for the development of additional new software in the DA Development area. It is expected that this new software can be developed with undergraduate hourly programmers. In the past, hourly programmers have been sufficient to develop DA software.

The DA Production Programs (Router, Printer Plot, and Post-pro) are being run at the University on the third shift. During this quarter, the last of the operational difficulties in running the Burroughs programs on the University's B5500 seem to have been ironed out. The MDS 1103 Data Link has come up to full operational status, and data is flowing in both directions with no difficulties.

Work has started on a program called Logic Systems Designer's on Line Testor. This program will use the logic model built by the Delay Check Program and will act as an Information Retrieval Program to allow the Logic Designer to examine the logic nets after layout has been finished.

5.6 Operating System

The specification of the ILLIAC IV operating system was completed in this quarter and has been described in a report. The report describes those sections residing principally on the B6500 computer--the job parser, program collector, disk file allocator, data processor, execution monitor, job partners, and hardware supervisor--and the sections of the operating system resident in the ILLIAC IV - OS4 and the loader. A brief description of the ILLIAC IV hardware and discussions of file security and interactive uses of the ILLIAC IV are also included.

The operating system group is obligated to furnish a workable version of the operating system on or about 1 October 1969. To this end a schedule has been formulated. The tasks to be performed were sorted into four groups.

1) Those tasks which appear to require minimal research

   a) Job Parser
   b) Disk File Allocator
   c) Data Processor
   d) Execution Monitor

   Deadline: Completely designed, coded, and partially debugged by 15 June.

2) Those tasks requiring intimate knowledge and closely connected design

   a) Loader
   b) Program Collector
   c) OS4

   Deadline: Complete specification by 1 June. Coded by 15 August.

3) Those tasks requiring further design and/or research

   a) Hardware Supervisor
   b) Job Partner
   c) Execution Monitor

Deadline: The research has the same deadline as task 2. The current version of the job partner given in the Operating System Description will be coded. No firm deadlines have been set on this sub-task.

4) Those tasks relating to the implementation of the system

a) Debug - Simulator

Deadline: Feasibility and desirability must first be assessed. However, a preliminary version is to be completed by 15 June to be of use in debugging the sub-tasks of task 1.

Major reviews of the development of the system are scheduled in May and June. By mid-June the entire design will be fixed, and a sizable portion of the system will be in the coding stage or beyond.

5.7 Translator Writing System

Some small changes have been made to the BNF → FPL syntax preprocessing algorithm and to its implementation. These changes have improved the speed and efficiency of the syntax preprocessor. Further changes which will increase the class of grammars acceptable to the system and improve the automatic error recovery are presently being considered and/or implemented. A first stage of documentation of the syntax preprocessor has been completed (Department of Computer Science Report No. 304) and further documentation is continuing.

The generation of parser pseudo-orders was modified to implement "one fell swoop" tests whenever there is a list of different single symbols to be tested in either the lookahead or the main stack followed by the same action in each case. This is accomplished by setting bits in a packed Boolean array row in the preprocessor. In the parser, the symbol to be checked is used to see if its bit in the appropriate row is "on."

A TRANQUIL compiler has been implemented and is currently being used to improve the system.

The work on TWINKLE is proceeding. The syntax specification has been made and is constantly being improved, and semantic routines are being written.

A new precedence function has been added to TWST in order to express the notion of operator precedence in a more compact form than at present. Several other primitives have been introduced including one to compare two atoms of an input stream without the atoms concerned being reserve words. For example, the identifiers which begin and end a PL1 compound statement could be compared directly by using TWST syntax instead of semantics.

Extensive tests have been run on ISL translators generated by the TWS system. Since ISL was the first, reasonably large language completely implemented using the TWS system, more realistic speed measurements could be performed on it.

Three different kinds of parsers can be used in compilers generated using the TWS system.

1) The first type of parser is a "slow" interpretive parser with a good error recovery which is designated PARSERI. This parser reads and executes a stream of coded orders called "parser instructions".

2) The second type of parser is a "fast" directly coded parser with good error recovery and is designated PARSERE. In this version the actions performed are the same as in PARSERI but, instead of reading parser instructions, PARSERE contains such instructions directly coded in ALGOL.

3) A "fast" directly coded parser with fair error recovery which is designated PARSERF is the third type of parser. This is similar to PARSERE except that some error recovery facilities are dropped in order to gain some speed for production runs; PARSERE would be used for debugging runs.

For an ISL compiler, using as input a "typical" ISL program with 2000 cards, the results were:

Type of Parser	Speed in Cards per Minute of Processor Time
PARSERI	452
PARSERE	520
PARSERF	524
"brute-force" ISL translator	2056

These results suggest the following guidelines for further development of the system:

1) Since PARSERE and PARSERF run at practically the same speed, PARSERF could be dropped.

2) Although PARSERE runs somewhat faster (processor time) than PARSERI, the total time in the machine is longer since PARSERE yields an extremely large compiler; moreover, PARSERE cannot be multiprocessed while PARSERI multiprocesses very well. This points to PARSERI as the most promising type of parser and efforts are being initiated to improve it.

Finally, it could be noted that the "brute-force" ISL translator runs four times faster than the TWS generated compilers.

5.8 Compilers and Translators

5.8.1 TRANQUIL

During this quarter, work in the pass 2 semantics for the TRANQUIL compiler continued. Progress was slowed, in part, by the frequent unavailability of the B5500 and its increasingly heavy usage.

Work has been initiated on the development of a more generalized data mapping declaration which will permit skewing an array an arbitrary distance based on the array size. Work has also been started on the implementation of all set operations.

Procedures to handle efficient utilization of PE registers during the evaluation of arithmetic expressions have been completed.

Several minor modifications were made to the syntax of TRANQUIL. Included in these changes was the addition of a new set

declaration, PATSET, for pattern sets. A pattern set is a multi-dimensional set that will be stored in ILLIAC IV as a mode pattern and may be used to access scattered array elements. The maximum range for the values of each dimension of the set may now be specified in a manner analogous to array subscript bound declarations. A lower bound of 1 is assumed if none is specified. All ALGOL coding for the declaration and definition of sets is now complete.

The storage allocation and array partitioning algorithms have also been slightly modified. They will now provide for array type data to be partitioned into blocks 128 x 128 words but stored completely within one quadrant of the ILLIAC IV. An array declared to be 150 x 150 would now be partitioned and arranged in PE memory (see Figures 1 and 2). The algorithms themselves are used only in the calculation of the PE number and row number for a particular array element. The block number computations remain unchanged.

5.8.2 GLYPNIR

The GLYPNIR compiler is now in the final stages of debugging. The full compiler for Version I is running, and the code generated by it is being checked and simulated. A user's manual for Version I is now being printed and should soon be released.

Work is also starting on Version II, which will include many extensions to the basic language as well as a faster compiler and better debugging facilities. The extensions, on which work has been started, include more flexible subroutine and control statements, as well as some basic I/O statements.

5.9 Graphics

A serial algorithm for doing shadowing by multiple point light sources of objects as well as half-tone and hidden plane consideration is near finalization. It also considers such things as direct reflection, transmission (transparent or semi-transparent objects), and color. No such algorithm yet exists for serial (or parallel) machines. Parallel

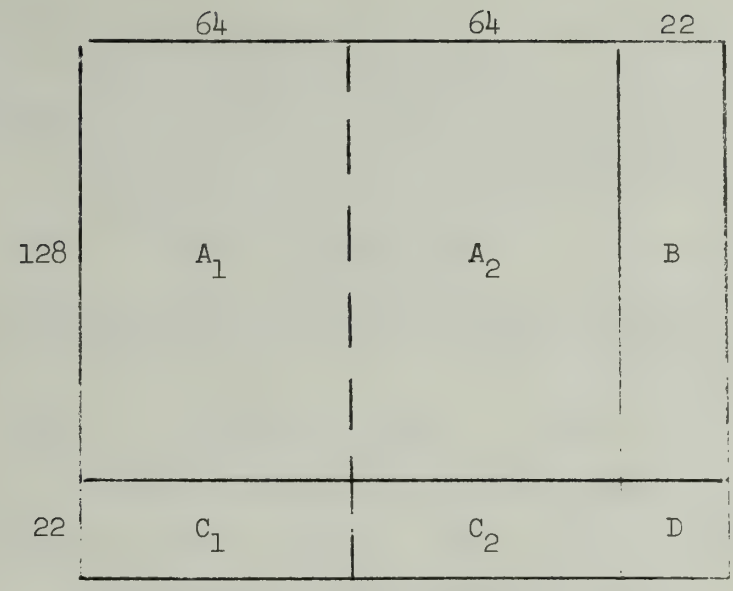

Figure 1. Array

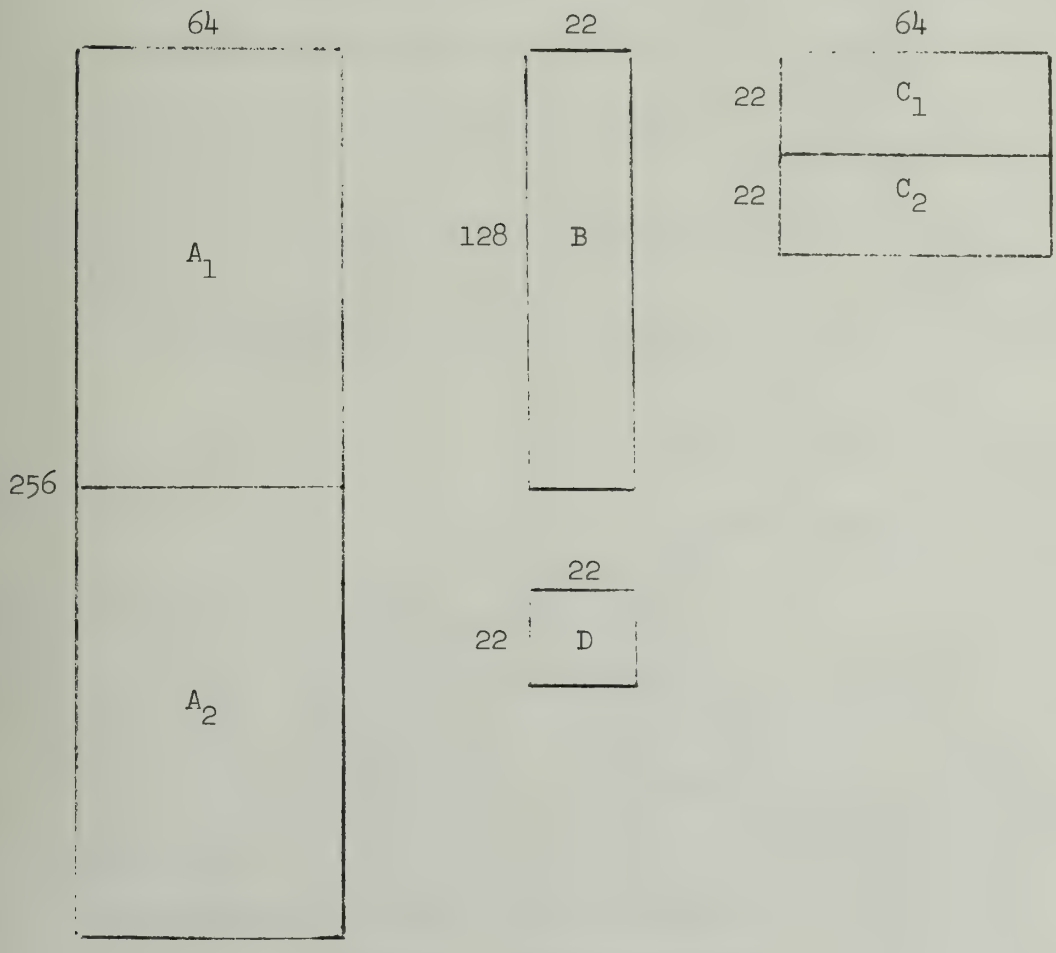

Figure 2. PE Memory Blocks

processing considerations are being examined and look somewhat promising. A preliminary language for describing geometric input and desired calculation is also being developed concurrently, with thought being given to an interactive real-time graphics display system.

5.10 Assembler

The Assembler is currently running on the B5500 and enjoys a large complement of users.

A reference manual has been written for the ILLIAC IV Assembler. It gives a preliminary specification for the basic ILLIAC IV Assembly Language, ASK version II. Included in the manual are:

1) a syntactic description of an ASK program,
2) a definition of assembly-time arithmetic,
3) a definition of assembly-time functions (pseudo-operations),
4) a definition of assembly-time utilities (control cards), and
5) examples of system control cards necessary to use ASK.

The document assumes some prior familiarity with ASK and a complete familiarity with the instruction set for ILLIAC IV as defined in the ILLIAC IV Systems Characteristics and Programming Manual.

5.11 Utility Data Processing

5.11.1 Disk Storage Allocation

A model has been developed and specified for a computer having a fixed-head disc-type of secondary memory. The purpose of this model is to allow optimization of I/O times for programs which require large amounts of input and output. The model permits this problem to be formulated as a linear programming problem. The LP formulation is relatively general in that it allows for various (computationally equivalent) reorderings of the original code as well as parameterization of memory and data transfer characteristics of the particular system being modelled.

5.11.2 Geometric Specifications

The geometry specifications processor is being revised to a preprocessor form in an attempt to allow the large number of otherwise serially performed compiler time computations to take place in parallel on the ILLIAC IV at run time. Also the power of what can be specified in the geometry specifications will increase since regular TRANQUIL arithmetic and control statements will be allowed but perhaps in a modified form.

5.12 Numerical Analysis

5.12.1 Ordinary Differential Equations

Work is proceeding on an automatic integrator for ordinary differential equations for ILLIAC IV. This program will accept as input a set of ordinary differential equations and initial values and will produce an assembly code to solve them. The object is, of course, to best utilize the inherent parallelism of ILLIAC IV in solving these equations. A simple example will show some of the problems involved.

$$y_1' = a\, y_1\, y_2 + k + c \qquad y_1/y_2$$

$$y_1' = d\, y_1 + b\, y_1\, y_2 + d\, y_2$$

To solve these equations on a two processor machine, it is desirable to evaluate the first term of the first equation and the second term of the second equation together. The other terms could also be done partly in parallel. On a larger system this becomes more complex. The automatic integrator program will do the necessary analysis to obtain the maximum efficiency. Another problem is that the equations may vary greatly in the number of terms. Thus work must be shared between processors. The program is designed to work on first order systems. (It can be shown that a higher order equation can be reduced to a first order system of equations.)

The part of the program which analyzes the equations and allocates storage so as to make best use of the machine has been completed. The scanner portion which must parse the input given in the form of a statement of the equations and initial values has been written using the Translator Writing System. Development is now proceeding on the numerical methods to be used for integrating these equations. It is planned to provide some type of predictor-corrector method as well as a single-step method.

5.12.2 Multidimensional Compressible Hydrodynamics

The one dimensional program on the B5500 has been recoded to run on the 360/75 using the Calcomp plotter. So far, satisfactory results have been obtained for the constant velocity piston problem. The rest of the test problems of Hicks will be run on the 360/75 as soon as possible using the OIL, donor, and continuous rezone difference schemes. Also, the coding of these algorithms into two dimensional cylindrical coordinates with axial symmetry has been started.

Further results were obtained on the B5500 using the continuous rezone method which indicated that this method yields results as good as, or better than, OIL and donor. Various methods were tried to improve the basic algorithm of continuous rezone to give better results for the collision-of-two-shocks problem. In particular, the case in which the velocities of two adjacent cells have opposite signs was examined and several modifications tried. However, none of these were an improvement over the standard method.

5.12.3 Eigenvalue Problems

The "Triangular-Skew" method has proved to be the best storage scheme in Jacobi's method for eigenvalues of symmetric matrices. With this method of storage, the origin of the matrix is moved two locations to the right and one location down after each transformation of the matrix. After each such displacement of the matrix, the elements must be accessed each time as needed. To accomplish this, a function f calculates, at the start of the program, the PE number and location of each element as functions of the matrix indices of the element. Then a function g calculates the new PE number and location as functions of the original PE, the location, and the number of transformations done.

Take a random element (m,p) of an n x n matrix. Then

$$f(m,p) = (\text{location, PE number}) = (L_0, P_0)$$

and

$$g(f(m,p)) = g(L_0, P_0) = (L_1, P_1)$$

$$g^2(L_0, P_0) = g(L_1, P_1) = (L_2, P_2), \text{ and so on,}$$

where

$$f(m,p) = \begin{cases} (m - 1, [-n \left\lfloor \frac{p+m-2}{n} \right\rfloor + p + m - 2]), & 1 \le m \le \frac{n}{2} \\ (m - 1, \quad p - \frac{n}{2}), & m = \frac{n}{2} + 1 \\ (p - \frac{n}{2}, \quad m + p - n - 1), & \frac{n}{2} + 2 \le m \le n \end{cases}$$

$$g(L_s, P_s) = ([L_0 + s - (\tfrac{n}{2} + 1) \left\lfloor \frac{L_0+s}{n/2 + 1} \right\rfloor], [-n \left\lfloor \frac{P_0+2_s}{n} \right\rfloor + P_0 + 2_s]),$$

where s denotes the number of the transformation, and $\lfloor \ \rfloor$ denotes integer arithmetic.

5.12.4 Monte Carlo Transport

During this period, a one-dimensional Monte Carlo radiation transport code, which includes scattering, was written for the B5500. The purpose for developing this program was to gain a thorough understanding of the difficulty involved in the Monte Carlo formulation. This code will be expanded to include two dimensions and then will be programmed for ILLIAC IV.

5.12.5 Polynomial Root Finding

During this quarter, work began on testing the polynomial root finding algorithm, previously developed, to determine what course of action needs to be taken when the method fails or when the polynomial is ill-conditioned. The algorithm is divided into two parts: (1) a multisectioning method, previously described, for locating simple, real roots of polynomials with real coefficients and (2) a complex integration procedure which divides a closed contour in the complex plane into

sixty-four partitions and then determines the number of roots in each partition. This method is based on the theorem that:

$$S_n = \frac{1}{2\pi i} \int_C z^n \frac{f'(z)}{f(z)} \, dz = \sum_{i=1}^{v} z_i^n$$

where the z_i's (i = 1, ..., v) are the zeroes of f(z) which lie in the interior of C, a closed contour in the complex plane. If n = 0 then S_o is merely the number of zeroes (minus the number of poles) of f(z) on the interior of C. This integral can be evaluated using the trapezoidal rule since the accuracy needed is to the nearest positive integer.

The method fails when a zero is too close to the boundary of the contour C because $F(z) \to 0$ and $|f'(z) / f(z)| \to \infty$. This necessitates halting the integration and relocating the contour. Work is also being done to determine a partition algorithm which will ensure a better rate of convergence.

5.12.6 Numerical Quadrature

A program has been written in ILLIAC IV Assembly Language to implement Romberg Integration. The user supplies an error tolerance along with the required parameters and a subroutine to evaluate the function to be integrated. Efficiency is achieved by evaluating the function at a large number of points simultaneously and then picking up the values as needed to form the trapezoidal sums which are used to calculate the integral from the standard Romberg formula. If the accuracy is not achieved, additional trapezoidal sums are formed until the necessary accuracy is realized. The basic Romberg reduction is not highly efficient, but if the functions to be integrated are complex, the overall efficiency will be high due to the method of evaluating the function.

5.12.7 Mathematical Subroutines

Using codes and the ILLIAC IV document "New and Revised Mathematical Subroutines for ILLIAC IV" written by Michael Katz, the

subroutines for 64-bit cosine, arc-tangent, sine, and square root were recoded, debugged, and simulated to the stated accuracy. The sine-cosine routine uses seven terms in the Chebychev expansion to obtain decimal significance equivalent to the argument. The sine-cosine scheme requires 1331 words of storage. The square root routine uses three Newton-Raphson iterations for 64-bit accuracy with fewer iterations available for less accuracy, if desired, and it requires 1321 memory locations.

Work has also begun on writing new routines, including log, arc sine, arc cosine, and others. The most common functions will also be written in double precision. An ALGOL code that converts the simulator's octal output to decimal format was written and used in debugging these routines.

The study of double precision arithmetic operations on ILLIAC IV was started during this quarter. The data format is as follows: each operand is expressed by a pair of high and low-order 64-bit, floating point numbers in such a way that the 96-bit mantissa of the operand is put in each mantissa part consecutively, and the exponent of the high-order part is that of the operand and larger than the next low-order part by 48. This data format in double length is kept throughout each arithmetic operation. In other words, data could be always a combination of two consecutive PE-memory words.

Addition and subtraction programs have been written in Assembly Language using EAD and ESB instructions, respectively. Timing is estimated at 70 clocks. For multiplication two versions have been coded. One of them is intended to obtain a result of quadruple length. Only the first two higher-order parts can be obtained by the other program. Timing for this program is estimated to be 80 clocks. Some of the above programs have been simulated and further study on multiple precision division is being considered.

Work has continued on significant digit arithmetic during this quarter. Codes for SDA multiplication and division have been simulated. Timing estimates for multiplication and division are three and six microseconds, respectively.

5.13 Linear Programming

During this quarter, the following LP algorithms have been completely defined and set up for implementation on ILLIAC IV:

1) primal,
2) dual,
3) right-hand-side parametric programming,
4) cost row parametric programming, and
5) right-hand-side and cost-row simultaneous parametric programming.

The effort of coding the algorithms is proceeding with significant progress in the tasks of refining coding specifications for portions of the minor iteration procedure and in the interfacing of the various interconnected sections of the code. The coding specifications have been expanded to include free, bounded, and fixed variables, in addition to the standard unbounded variables. This involved revision of pivot selection rules and procedures for updating the basis, right-hand side, and objective function (cost row). These revisions have been partly incorporated in the code.

The interfacing of the different sections of code is largely a problem of memory allocation, communication, and standardizing internal data formats. PE memory for buffers, work areas, and common tables has been allocated for maximum overlap of common data utilization. I/O is coordinated among subroutines so that as much I/O as possible is masked by other machine operations. Certain I/O procedures have been generalized and isolated for use by all portions of the program through common data and buffer regions.

The preprocessing of input data for ILLIAC IV has been analyzed, and an ALGOL program to prepare input data files has been written and is being debugged. This program will scale rows and columns to reduce all bounds to a common value of 1 and to minimize the size-range of coefficient values. Tables will also be prepared to allow postprocessing of the solution on the B6500.

As a first step in the process of code-testing, test matrices with known solutions have been prepared and formatted in a way acceptable

to the preprocessor. These will provide a data base for code-testing during the next quarter.

Round-off errors are an ever-present problem in LP computation, so a study is presently under way to find methods of increasing the numerical stability of solutions. The methods under consideration are iterative refinement of intermediate products of the solution steps and L-U decomposition of the basis inverse.

During the next quarter, it is expected that simulation of the code on the B5500 will be commenced.

5.14 Long Codes

During this quarter, the study of stability of linear Hamiltonian systems was completed. The following is a summary of the study.

A linear Hamiltonian system with a periodic coefficient matrix may be defined by:

$$\dot{Y}(t) = J\ H(t)\ Y(t)$$

where

$$J = \begin{bmatrix} 0 & I \\ -I & 0 \end{bmatrix},$$

$H(t) = H(t + \omega)$ is a symmetric matrix of order $2k$,
$Y(t)$ is the normalized solution of the system (Matrizer), and
$Y(0) = I$.

The above Hamiltonian system is stable for all time t, in the sense that the solutions $Y(t)$ do not grow with time and remain bounded as $t \to \infty$, if and only if all the eigenvalues of the monodromy matrix $Y(\omega)$ have unit modulus and all the elementary divisors are linear, i.e., if $Y(\omega)$ may be reduced to a diagonal matrix by a normal transformation.

The monodromy matrix $Y(\omega)$ of the above Hamiltonian system is defined by

$$Y(t + \omega) = Y(t)\ Y(\omega) \ .$$

Moreover, for the Hamiltonian system

$$\dot{X}(t) = J\ H(t)\ X(t)$$

where $X(t)$ is any fundamental matrix of the system, then it can be proved that

$$X(t) = Y(t)\ X(0) \ ,$$

where $Y(t)$ is the matrizer of the system and consequently $Y(t)$ is a canonical transformation which in turn can be shown to be a symplectic matrix. Symplectic matrices form a group under multiplication and the most important properties of such matrices are:

i) $Y^{t}\ JY = J$

ii) $\det(Y) = +1$.

The monodromy matrices of a system form a group under similarity transformations, and, hence, the eigenvalues of all the monodromy matrices of a given system are the same. The eigenvalues of a monodromy matrix are called the multipliers of the system and they are invariants of the system.

The above concept of stability rarely meets the requirements of any physical application. Therefore, the differential equations of motion are known only approximately, and, consequently, one needs a stability concept which allows for small changes of the equations. Such a stability concept is called Parametric stability or Strong stability.

A canonical system

$$\dot{Y}(t) = J\ H(t)\ Y(t)$$

is called parametrically stable if it is stable and if there exists an $\epsilon > 0$ such that for any real symmetric matrix $H(t)$, with piecewise continuous elements, satisfying the condition

$$\tilde{H}(t) = \tilde{H}(t + \omega) \text{ and}$$

$$\|\tilde{H}(t) - H(t)\| < \epsilon$$

(where $\|B\|$ is to be understood as $\max |\beta_i(t)|$, where $\beta_i(t)$ are the eigenvalues of $B(t)$), all solutions of the system

$$\dot{Y}(t) = J \tilde{H}(t) Y(t)$$

are bounded as $t \to \infty$.

As can be seen from the above definition, parametrically stable systems form an open set in the set of all canonical systems. Thus the conditions of parametric stability can be stated as follows.

> The system $\dot{Y} = J H(t) Y$ is parametrically stable if and only if the following three conditions are satisfied.
>
> 1) The monodromy matrix $Y(\omega)$ is diagonalizable,
> $D = F^{-1} Y(\omega) F = \text{diag}(\lambda_1, \lambda_2, \ldots, \lambda_{2k})$.
>
> 2) All the eigenvalues of $Y(\omega)$ lie on the unit circle, i.e., $\lambda_s = e^{i\omega\beta_s} = e^{i\theta s}$.
>
> 3) Since $Y(\omega)$ is real and also symplectic, then by Liapunov-Poincaré theory, the eigenvalues of $Y(\omega)$ appear in complex conjugate pairs. Therefore, the third condition is: Repeated multipliers of the unlike type do not occur on the unit circle. The term "unlike type" means multipliers that leave the circumference of the unit circle in opposite directions under a complex perturbation of the coefficient matrix $H(t)$.

Condition (3) therefore can be put in any of the following forms:

a) $\lambda_{s'} \neq \bar{\lambda}_{s''}$ $\qquad (s', s'' = 1, 2, \ldots, k)$

b) $\theta_{s'} \neq -\theta_{s''}$
(assuming that the eigenvalues are arranged as $\lambda_1, \lambda_2, \ldots, \lambda_k; \ \bar{\lambda}_1, \bar{\lambda}_2, \ldots, \bar{\lambda}_k$).

c) $\sum_{s=1}^{k} \lambda_s^{g_s} \neq 1$

where, g_s are integers such that

$$g_s \geq 0, \quad \sum_{s=1}^{k} g_s = 2.$$

d) The quadratic expression (inner product), $(-iJh, h)$ on the eigen-subspace corresponding to a repeated multiplier of multiplicity r is sign-definite, where

$$h = \sum_{v=1}^{r} \alpha_v f_v$$

and f_v are the eigenvectors of $Y(\omega)$ corresponding to the repeated multiplier.

Furthermore, the question of the "Regions of Parametric Stability of Linear Hamiltonian Systems" was studied in detail. This question arises from considering the conditions under which there exists a symmetric matrix $H(t,v)$, piecewise continuous in t and continuous in v such that:

$$H(t,0) = H_1(t)$$

$$H(t,1) = H_2(t)$$

and such that the system

$$\dot{Y}(t) = J\, H(t,v)\, Y(t)$$

where,

$$H(t + \omega, v) = H(t,v) \qquad 0 \leq v \leq 1 ,$$

is parametrically stable for all v, $0 \leq v \leq 1$.

It can be shown that the above system is parametrically stable if $H_1(t)$ and $H_2(t)$ belong to the same stability region. A stability region is characterized by an integer n,

$$n = \left(\frac{1}{2\pi}\right) \left[\text{Arg det } Z(t) \Big|_0^{\omega} - \sum_{s=1}^{k} \theta_s \right]$$

where,

$$\text{i)} \quad Z(t) = \left(-iJ\ Y(t)h_\nu,\ h_\mu\right) \qquad \nu,\mu = 1, \ldots, k$$

and $(h_1, h_2, \ldots, h_k)$ is an arbitrary basis in the subspace spanned by the eigenvectors of $Y(\omega)$ corresponding to the multipliers of the first kind $e^{i\theta s}$, $s = 1, 2, \ldots, k$ (i.e., those eigenvalues that leave the circumference of the unit circle towards its interior under complex perturbations of $H(t,v)$).

$$\text{ii)} \quad \text{Arg det } Z(t) \Big|_0^{\omega}$$

means the change of the argument of the determinant of Z(t) over the period (ω).

5.15 Graphics

5.15.1 Software

The basic algorithm for the hidden line elimination has been developed on the B5500. A simple, fast algorithm is essential because there are today many applications for which it is desired to view a moving object on a CRT. The old hidden line information, which is

calculated once, has not been used for the subsequent computation of the hidden lines if the objects are translated or rotated about some axis. With the present methods, the computations are started over again to calculate the hidden parts for a transformed object.

The relationship between two polygons is changed whenever the rotation about the y-axis causes the plane perpendicular to the view plane to pass critical planes. The problem is how to find those critical planes for each pair of polygons. The algorithm for this has been developed. The program for a rotating object will be implemented on the B5500. This critical plane method is expected to lead to a great reduction of computation time for the hidden line elimination of a rotating object.

5.15.2 Language

The concept of the language for representing three dimensional objects has been developed. To date, users have had to give detailed data consisting of the coordinates of vertices and the description of the relationship between faces, edges, and vertices. With this language, complicated three dimensional assemblies are easily expressed by a few simple operations among some geometric operands, i.e., convex primitive solids. Each object has its own coordinate axes. The connection of primitives and the relationship of assemblies are easily expressed by the relative coordinates. Of course, the absolute coordinate expression is also possible. The overlapping of two objects in the physical world can be checked, and the adjustment can be done automatically. Furthermore, because of these features, this language will also be used in the case of the man-computer direct interaction through a cathode ray tube and a keyboard. The data structure of the language is rather complicated, but the level structure of faces and the use of convexity or concavity of solids reduce the computation time of the hidden line elimination.

5.16 Radar Data Processing

During this period, time has been devoted to reprogramming the Kalman Filter in a version in which everything is kept in spherical radar

coordinates; to programming the fast fourier transform using the Cooley Tukey algorithm for both radar and seismic signal processing; and to reprogramming the time filter designation mode in radar floating point coordinates. The final report from Auerbach Corporation on the study of using ILLIAC IV for the BMD radar signal processing operations was received; however, it had to be returned for rewrite.

At the beginning of this time period, the new version of the Kalman Filter algorithm was adopted. It performs all calculations in radar coordinates, which eliminates any coordinate conversions. For this reason, it seems to be a better algorithm and has proven to be somewhat easier to code. Information on this algorithm and data generated by it were acquired from Lincoln Laboratory. An ALGOL version of the program was immediately coded and completely debugged, and is being used to create partial results to aid in debugging ILLIAC IV Assembly Language code.

The ILLIAC IV Assembly Language version of the Kalman Filter algorithm is presently being debugged on a newly available execution and timing simulator. The simulator is still unreliable to some extent and has caused much slowdown in progress. Some portions of the assembly code are completely debugged, and some preliminary timings have been made. Debugging and timing is expected to be completed by the end of the next time period.

The FFT (Fast Fourier Transform) algorithm has been programmed in ALGOL for the B5500 and in ILLIAC IV Assembly Language ASK as a general subroutine which can be used for both radar and seismic signal processing. The version programmed in ASK is presently being debugged by using the ILLIAC IV simulator.

5.17 Seismic Signal Processing

A series of programs have been written in B5500 ALGOL to provide data for later use in testing and debugging ILLIAC IV programs. This series of programs is functioning and is now being written in ILLIAC IV Assembly Language. The programs are:

1) Auto Correlation: used to generate an auto correlation function of both individual and summed seismic traces. Such functions are used in deconvolution to determine filter weights, in the determination of the power spectrum of the trace, to determine the presence of multiple reflections, for wavelet compression, and for reverberation minimization.

2) Cross-correlation: used in filter applications and in establishing amplitude spectra of periodic signals.

3) Convolution: filter operators derived through the use of the auto correlation function are convolved with the signal trace resulting in wavelet compression and reverberation minimization.

4) Sine and Cosine Wave Generators: used to obtain sine and cosine transforms and Fourier amplitude and phase spectra.

5.18 Statistical Packages

During this quarter, work was begun on a rudimentary scanner for the input language for the ILLIAC IV statistical system. This language will, in general, use blanks as delimiters and will limit the use of other special characters. It will derive its information content primarily from positional interrelation of key words. This type of input will allow an input program to resemble more closely a natural language string. The effect of this will not be large in the limited area of statistics, but this will allow further development of an information retrieval language with a much broader purpose and which will be at least syntactically compatible with the base statistical language. The ultimate aim would be to provide almost natural language instruction to a data retrieval system which would operate in conjunction with a file maintenance system to generate input for the statistical system.

The second area of study for this quarter was data management systems. In particular, the use of DL/1 in conjunction with the Rockland State Hospital (Orangeburg, New York) mental patient file was observed.

The specifications of the original DM/1 system were also studied. Data management and its file maintenance currently represent one of the largest problem areas in the computer field. Since it is expected that large scale data bases will be used in connection with the ILLIAC IV statistical system, the feasibility of a data management system for ILLIAC IV is being studied.

5.19 Education

Again this quarter two courses were organized and offered by the ILLIAC IV Education area of the Project. The CS 491-D course, which covered the hardware, languages, and applications of the ILLIAC IV, and a course for new ILLIAC IV staff which covered the ALGOL language and methods of running programs on the B5500 were offered. A new development in this area was that the CS 491-D course was offered university-wide, and almost half of the students enrolled were non-ILLIAC IV staff.

A project has been undertaken to formulate the material covered in the CS 491-D class into a document which will be made available to people interested in learning about the ILLIAC IV project.

In the last Quarterly Progress Report, the initiation of the attempt to collect and categorize all the programs written for the ILLIAC IV machine was mentioned. This, along with the effort to compose another TRANQUIL manual, is continuing.

THESES

Beals, Alan J. "The Generation of a Deterministic Parsing Algorithm." Master's thesis, DCS Report No. 304. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Budnik, Paul P. "TRANQUIL Arithmetic." Master's thesis, DCS Report No. 296. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Muraoka, Yoichi. "Storage Allocation Algorithms in the TRANQUIL Compiler." Master's thesis, DCS Report No. 297. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Trout, H. Robert G. "A BNF Like Language for the Description of Syntax Directed Compilers." Master's thesis, DCS Report No. 300. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Tummelson, Jay M. "An Algorithm for Delay Checking Computer Designs." Master's thesis, DCS Report No. 301. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Wilhelmson, Robert. "Control Statement Syntax and Semantics of a Language for Parallel Processors." Master's thesis, DCS Report No. 298. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

DOCUMENTS

Katz, Michael L. "New and Revised Mathematical Subroutines for ILLIAC IV." ILLIAC IV Doc. No. 210, DCS File No. 787, (January 27, 1969).

Lawrie, Duncan H. "Glypnir Operation Manual." ILLIAC IV Doc. No. 213, DCS File No. 792, (March 10, 1969).

McCarthy, Thomas. "Solving a Set of Ordinary Differential Equations Involving a Large Matrix." ILLIAC IV Doc. No. 209, DCS File No. 786, (January 27, 1969).

Northcote, Robert S. "Software Development for the Array Computer ILLIAC IV." ILLIAC IV Doc. No. 214, DCS Report No. 313, (March 12, 1969).

Westlund, G. A., et al. "A Description of the ILLIAC IV Operating System." ILLIAC IV Doc. No. 212, DCS File No. 791, (March 10, 1969).

Yasui, Toshio, and Winje, Gilbert L. "Significant Digit Arithmetic on ILLIAC IV." ILLIAC IV Doc. No. 211, DCS File No. 789, (February 18, 1969).

6. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL LANGUAGES

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6.1 Computerized Mathematics

There have been several strategies proposed for applying the resolution principle given by J. A. Robinson to prove theorems on a computer. These strategies often restrict the form which an acceptable proof tree may have, thereby reducing the number of clauses which need to be generated. It is desirable for a strategy to satisfy a completeness property of the following form: if the input set of clauses is inconsistent, the strategy is guaranteed to find a proof tree. Typically, such a theorem is proved by rewriting proof trees which already are known to exist but which may not have the special form required by the strategy. However, rewriting a deduction may introduce tautologies, and most theorem proving programs do not save tautologies. Thus, there is a serious gap between general practice and what has been proved.

In the last quarter we have been able to show that the set of support strategy will yield a tautology free proof of an inconsistent set of clauses if the complement of the set of support is consistent. We also gave an example of an inconsistent set of clauses S and set of support T where S-T was not consistent for which there did not exist a T supported proof of S containing no tautologies. Another promising strategy is resolution with merging. It is known that this strategy is complete in the above sense, but the proof requires the rewriting of trees. We have been trying to give an alternate proof which will also show that tautologies are not needed. We hope to complete this proof in the next quarter and publish the results.

(L. J. Henschen)

6.2 Numerical Solution of Singular Integral Equations

An analytical solution to the linear singular equation (with Cauchy kernel) exists if the given function, the coefficient functions,

the bounded part of the kernel and the solution space are all assumed to be Holder continuous.

Thus in order to be able to apply the abstract uniform approximation theory of Anselone, we restrict the space of functions on which we operate to the space of Holder continuous functions. In this space we can show that the dominant part of the operator is a bounded linear operator mapping the space into itself, and the remaining part is a completely continuous operator on the space.

For the discretization of the operator for a numerical method, two approaches have been outlined which attempt to exploit the symmetric properties of the singularity of the kernel. Further study of these discrete operators will show which is a more effective approach, and whether in fact they can be put in a form to satisfy the conditions for the uniform approximation theory.

(A. W. McInnes)

6.3 Study of Methods of Selection of Quotient Digits During Digital Division

This study concerns a class of division techniques in which redundancy is introduced into the representation of the quotient thus permitting quotient digits to be selected by inspection of estimates of the full precision divisor and partial remainder.

Research during this quarter has concentrated on mechanisms in which an estimate of the divisor is used to generate an estimate of the reciprocal of the divisor which is then multiplied into the estimate of the partial remainder and rounded to produce a quotient digit. Table look-up is used to generate the first estimate of the reciprocal of the divisor. If greater precision is required, the initial estimate may be improved using an iterative procedure.

An algorithm was developed and coded in FORTRAN IV which will generate an estimate of the logic requirements. The parameters to the program are the radix, the range of the divisor, the direction and magnitude of truncation error in the estimate of the divisor and partial remainder, and the degree of redundancy permitted in the representation of the quotient.

Preliminary results indicate that the cost of the table look-up is proportional to r, the radix and the cost of the multiplication hardware proportional to $\log_2 r$. This may be compared to the direct table look-up (reported in previous Quarterly Progress Report) in which the cost is proportional to r^2.

Manual analytic techniques were also used to help validate and interpret the results of the computer runs. Work is continuing in this area.

(D. E. Atkins)

6.4 Automatic Function Generation

The set of elementary function algorithms has been expanded during this quarter to include square root, cosine and sine, and arctangent. The square root algorithm can be performed in approximately one multiplication time, i.e., approximately R/3 addition cycle times (on the average), where R is the length of the fractional part of the operand. The square root algorithm does not require any new stored constants.

The cosine and sine functions are produced simultaneously. It was found that it is not efficient to perform the entire algorithm redundantly; the first quarter of the algorithm is done non-redundantly. A time estimate to form both cosine and sine of an argument in the range $(0, \pi/2)$ is two multiplication cycle times if three adders are available and slightly longer if only two adders are available. The algorithm can be performed with a single adder, but it would not be very efficient to do so. The cosine-sine algorithm requires storage of about R/3 additional precomputed constants, bringing the total for all algorithms developed to date to slightly more than 4R/3.

The arctangent of an argument in the range (0,N) where N is the largest number that can be represented in the machine in floating point can be formed, with three adders, in approximately one multiplication cycle time with no new stored constants being required.

It was found that the logarithm and exponentiation algorithms can be extended to the full range (rather than consideration of only the fractional part of the operand), at a cost of one additional multiplication in the case of logarithm and two additional multiplications for exponentiation.

Research is continuing on algorithms for arccosine, arcsine and tangent. Further research will include simulation of the algorithms, Monte Carlo estimates of efficiency, and study of implementation in a binary computer.

(B. G. De Lugish)

6.5 Development of Symbol Manipulation and List Processing Languages

Our experiences in transferring EOL from the IBM 7094 to the System 360 led us to the following approach for achieving a high degree of machine-independence for the implementation of EOL in particular, and list processing languages which operate on tree-structured data in general: to design a system, which is as simple as possible, yet sufficient in a practical sense, so that any high level language which operates mainly on tree-structured data, can be implemented in terms of it easily and efficiently.

Most of the design for such a system, called NUCLEOL, had been described in "NUCLEOL -- the Basis for the List-Processing Language EOL-4," by J. R. Sidlo (master's thesis), August, 1968.

Because of the intended use of NUCLEOL as a basis for other languages, its rigorous definition became crucially important. This was achieved in another master's thesis, "NUCLEOL as a Formal System," by M. Irwin-Zarecki (I. Irland), February, 1969. (Department of Computer Science Report No. 310).

The approach used is due to John McCarthy, and is also currently used for the formal definition of PL/1 by a group at IBM. Our definition of NUCLEOL, however, differs from other similar efforts in that the formal definition is actually part of the implementation of the language -- this provides a serious check on its accuracy and consistency.

NUCLEOL is described in a paper* presented at the Purdue Centennial Year Symposium on Information Processing in April, 1969.

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* Nievergelt, J., F. Fischer, M. I. Irland, and J. R. Sidlo, "NUCLEOL - A Minimal List Processor," Department of Computer Science Report No. 324, April, 1969.

Current efforts include the study of tree algorithms and an implementation of transformational grammars, both using NUCLEOL.

(J. Nievergelt, K. Maruyama)

6.6 Graph Algorithm Research

Software is being developed which will enable programmers to express graph algorithms in terms of graph concepts and operations. Most of the lower level graph operations deal with sets of objects, so the initial programming effort was to implement a system for performing set operations, and this was completed during this quarter. An initial collection of elementary graph operations was also completed and tested successfully by a non-trivial graph algorithm.

Operations on both sets and graphs are expressed only in terms of sets and graphs, and are independent of the actual representations used. Thus many graph algorithms can be coded in this representation-independent way, and combinations of (as well as comparisons among) different algorithms for the same problem can be made. Hopefully, this will lead to uniform measurements of efficiency of graph algorithms and graph representations.

This research also includes the survey of existing graph algorithms to determine common features and relevant concepts.

(S. Chase)

6.7 Switching Theory and Logical Design

I began research work with Professor Muroga's group on February 1, 1969. Much of the first month was spent becoming acquainted with the research area: logical design of an optimum network by integer programming.

During the middle of February I changed an existing program so that it was capable of optimizing* a network of (a given number of) AND-gates and OR-gates for a three variable function.

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* Here, an optimal circuit is one with the least total of external input connections plus gate interconnections.

Data for this program are the function which will be realized and the inequalities which are chosen to impose desired constraints on the network to be designed. I made up such data formulations for 2-, 3-, 4-, 5- and 6- gate networks. Each possible function of three variables (except degenerate ones) was run first with the 2-gate formulation and then with successively higher formulations until the function was realized. Hence for each function, its network was first optimized for the least number of gates and then for the least number of input connections and gate interconnections.

Diagrams for all optimal networks were drawn up.

Some experimentation was done with using a disk to save money and time by not reading in the program deck for each run.

Towards the end of the quarter, the main program was again converted; this time to optimize a network of NOR-gates for a four variable function. Experimental runs were made for 3-gate, 4-gate, and 5-gate formulations. Further research with four-variables is continuing.

(J. Culliney)

6.8 A Study of an Implicit Iterative Procedure Due to H. L. Stone

My work concerns a theoretical proof of a new iterative solution of implicit approximation of multidimensional partial differential equations of elliptic type.

The new method was first described in a paper by H. L. Stone (SIAM Journal on Numerical Analysis, September, 1968) and is based on a factorization of the matrix A + B, where A is elliptic, into a product L · U

where

L is lower diagonal matrix,

and where

U is upper diagonal matrix.

I also checked the new method on the computer, and I achieved very fast convergence.

(A. Bracha)

7. SWITCHING THEORY AND LOGICAL DESIGN

Logical design of optimum networks by integer programming has been continued by C. R. Baugh, J. N. Culliney*, T. Ibaraki, T. K. Liu, S. Muroga, T. Nakagawa and R. Swee (J. N. Culliney and T. Nakagawa joined and T. Ibaraki left the group in February) in a concerted effort since the following design problems are all closely related. We designed optimum networks for functions of three variables under the restrictions that AND and OR gates are to be used and x_i and $\bar{x}_i$ both are available at the inputs of a network (i=1, 2, 3). This design problem is very interesting because it is the most popular subject in textbooks of switching theory. In these textbooks it is approached by the minimization of a prime implicant expression, without guaranteeing the minimality of the number of gates. Our design approach by integer programming showed that the minimization of a prime implicant expression leads to non-optimum networks for two functions even among functions of three variables. We started to work on functions of four variables. The increase of computation time for the change from 3 to 4 variables appears relatively small. We started a new variation to design optimum networks with a mixture of different types of gates. Efforts to speed it up with various gimmicks have been made. A new formulation with a fewer prespecified gates has been found. Design of optimum networks in a restricted form of double rail logic (Each gate has the two outputs NOR and OR both but x_i's except $\bar{x}_i$'s are available at the inputs of network.) has been in progress.

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* J. N. Culliney is supported by the National Science Foundation grant of the number NSF-GJ-217.

A survey paper of logical design methods by integer programming is prepared by S. Muroga. This will be incorporated in the third volume of the series "Advances in information system science" edited by J. Tou (Plenum Press.)

C. R. Baugh continues to work on pseudo-threshold functions for his Ph.D. Thesis. He found many interesting properties of the functions, introducing the concept of trinal function.

F. Chen works on synthesis of multiple-output networks besides generalized threshold functions for his Ph.D. thesis.

T. Ibaraki and S. Muroga worked on synthesis with negative functions and published the result as departmental report number 309. Also the implicit enumeration algorithm of integer programming on Illiac IV was published as a report numbered 319.

Saburo Muroga

8. SOUPAC SECTION
(Statistically Oriented Users Programming and Consulting)

During the time period January 1 through March 31, 1969, there were 695 consultations with members of the SOUPAC staff. Of these, 119 were new consultees, a rather large increase for a three month period. A counter in the 7094 collection of programs indicated that 7800 jobs were run, in addition, nearly 100 manuals of instruction for the 7094 collection were distributed.

Copies of programs are being sent on request to Yale University, Florida State, University of Florida, University of Houston, and processing of data will be done for the Oregon Research Institute in Eugene, Oregon.

A series of weekly seminars were attended by members of the SOUPAC programming staff. The topics covered included: SOUPAC System and Monitor, Job Control Language, Machine Configuration and Disk Storage, Dumps, and the SOUPAC MATRIX program.

In addition to those programs already announced, seven more are now operational: PRINCIPAL AXIS FACTOR ANALYSIS, LINEAR PROGRAMMING, CLIQUE ANALYSIS, CLASSIFICATION, PROCRUSTES, COMMUNALITIES ESTIMATION, and the arithmetic sections of TRANSFORMATION. Temporary write-ups are now available for all the programs announced as operative.

Constant efforts are being made to make the SOUPAC System more efficient and comprehensive. Overhead has been decreased drastically by more efficient allocation of disk storage. A new SOUPAC monitor is being tested and will soon be operative. A SOUPAC-CalComp interphase is now working, and the possible implications of Multi-Task Processing on the IBM 360 for SOUPAC is being studied.

Kern W. Dickman
Project Director

9. IBM SYSTEM/360 SERVICE

(Supported in part by the National Science Foundation under Grant No. NSF-GP-7634.)

9.1 New Routines - IBM System/360

F2-UØI-LRCHZ-85F-F

Eigenvalues of a Symmetric Positive Definite (May be Band) Matrix by LR-Algorithm. This routine determines the eigenvalues of a symmetric positive definite matrix A using the LR-algorithm. It is particularly useful for band matrices.

Programmed by Beth Richardson
January 7, 1969

J5-UØI-PLØTTZ-87F-F

Simplified Plotting Subroutine. This program will enable those with little knowledge of the CalComp plotter to make use of the facilities on the System/360. The user supplies to PLØTTZ two arrays of matching X and Y coordinates for the graph he wishes to produce. A straight line is drawn successively through each of the N points whose coordinates are supplied in the arrays. In addition, axes are drawn and appropriate numerical values affixed at intervals.

Programmed by Al Whaley
March 24, 1969

G5-UØI-RAN3Z-57F-A

Pseudo-Random Number Generator. This program will generate a sequence of pseudo-random floating point numbers or full-word integers which appear to have been drawn from a population which is uniformly distributed. The method is that of Professor D. H. Lehmer (University of California, Berkeley).

Programmed March 24, 1969

C2-ANL-RSSR-88F-F

Root Finder for Polynomials with Real Coefficients, Including Multiple Roots. This routine is used to solve a polynomial equation with real coefficients, using root squaring and subresultant procedures.

Coded by Burton S. Garbow

March 24, 1969

Table I - IBM 360/20

Summary of Use

January, 1969

Scheduled Engineering		11:49
Unscheduled Engineering		31:20
Maintenance		3:58
Production		269:14
Operator Training		2:08
Idle		136:31
	Total	455:00

Table II - IBM 360/20

Summary of Machine Errors

January, 1969

2560 MFCM		17
2203 Printer		1
	Total	18

Table I - IBM 360/50-75

Summary of Use

January, 1969

Scheduled Engineering	36:16:51		
Unscheduled Engineering	13:55:00		
Maintenance	9:20:28		
Air Conditioning	7:35:00		
		Subtotal	67:07:19
Total Use			
Training and Education		135:07:24	
System Improvement and Modifications		112:30:16	
System Updating		14:26:14	
University Administrative Overhead Use		50:20	
Overhead		13:01:11	
Refund		3:15	
Customer Use			
In System	124:15:42		
Special Short Shots	2:26:11		
Customer Use Total		126:41:53	
		Total Use	402:40:33
		Total Time	469:47:52

Table II - IBM 360/50-75

Summary of Errors

January, 1969

75 Core		1
50 CPU		1
50 Main Frame		2
	Total	4

IBM 360/75 TABLE III JAN., 196[illegible]

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 360/75 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
AAE	470	279	749	5	6	11	4: 5: 2	5: 6:34	9:11:36
AGE	116	49	165	4	3	7	2: 3:40	0:22:59	2:26:39
AGEC	39	126	165	1	7	8	0:23:12	4:36:10	4:59:22
AGRON	334	183	517	1	5	6	2: 6:19	1:11:51	3:18:10
ANS	0	11	11	0	2	2	0: 0: 0	0: 2: 0	0: 2: 0
ARCH	159	0	159	3	0	3	1:35:12	0: 0: 0	1:35:12
ASTR	0	28	28	0	3	3	0: 0: 0	0:21:20	0:21:20
BECBSR	0	14	14	0	1	1	0: 0: 0	0:12:16	0:12:16
CE	722	766	1488	13	37	50	10: 4:38	19:55:30	30: 0: 8
CHE	211	687	898	6	21	27	4:44: 1	13:46:37	18:30:38
CRC	0	23	23	0	1	1	0: 0: 0	0: 8:18	0: 8:18
CSL	0	48	48	0	2	2	0: 0: 0	0:20: 4	0:20: 4
DCS	5295	209	5504	15	11	26	70:39:10	7: 4:16	77:43:26
DS	0	70	70	0	2	2	0: 0: 0	0:46:44	0:46:44
ECON	78	4	82	1	2	3	0:49:48	0: 8:32	0:58:20
ED	0	32	32	0	1	1	0: 0: 0	0:11:46	0:11:46
EDPSY	28	0	28	2	0	2	0: 4:40	0: 0: 0	0: 4:40
EE	936	340	1276	13	17	30	12:52:33	3:45:49	16:38:22
ENGADM	0	131	131	0	2	2	0: 0: 0	1:39:34	1:39:34
ENGCST	0	32	32	0	1	1	0: 0: 0	0:50:49	0:50:49
ENGH	310	0	310	1	0	1	1:12:25	0: 0: 0	1:12:25
ENGRDV	0	1	1	0	1	1	0: 0: 0	0: 0:26	0: 0:26
FT	0	26	26	0	3	3	0: 0: 0	0: 9:44	0: 9:44
GENE	336	0	336	4	0	4	2: 9: 8	0: 0: 0	2: 9: 8
GEOG	0	12	12	0	2	2	0: 0: 0	0: 3:29	0: 3:29
GEOL	153	140	293	2	2	4	2: 9:34	1:54:37	4: 4:11
GSBA	335	0	335	2	0	2	6:37:15	0: 0: 0	6:37:15

ICR	0	56	56	0	2	2	0: 0: 0	0:20:46	0:20:46
IE	24	0	24	1	0	1	0: 4:32	0: 0: 0	0: 4:32
ILLDMH	0	136	136	0	1	1	0: 0: 0	3: 6:26	3: 6:26
INADM	0	42	42	0	1	1	0: 0: 0	0:50:13	0:50:13
MATH	0	9	9	0	2	2	0: 0: 0	0: 1:22	0: 1:22
MATRL	0	458	458	0	13	13	0: 0: 0	7:26: 1	7:26: 1
MCBIO	0	8	8	0	1	1	0: 0: 0	0: 2:26	0: 2:26
ME	1536	313	1849	14	9	23	11:16:52	6:45: 4	18: 1:56
MKTG	0	18	18	0	2	2	0: 0: 0	0: 6: 4	0: 6: 4
MUSIC	0	3	3	0	1	1	0: 0: 0	0: 1:37	0: 1:37
NUCE	31	168	199	2	10	12	0: 8: 1	1:27:22	1:35:23
OIR	0	276	276	0	1	1	0: 0: 0	2:18: 9	2:18: 9
ORME	0	9	9	0	1	1	0: 0: 0	0: 1:50	0: 1:50
PHYB	0	131	131	0	2	2	0: 0: 0	3:53:35	3:53:35
PHYCS	10	544	554	2	10	12	0: 3:19	5: 4:11	5: 7:29
PHYX	0	644	644	0	26	26	0: 0: 0	19:50:36	19:50:36
POLS	19	37	56	1	1	2	0:28:19	0:28: 3	0:56:22
PSYCH	0	86	86	0	2	2	0: 0: 0	1:18:56	1:18:56
REC	0	7	7	0	1	1	0: 0: 0	0: 1:47	0: 1:47
SCONS	0	71	71	0	1	1	0: 0: 0	0:33:53	0:33:53
SGS	0	116	116	0	1	1	0: 0: 0	0:29:52	0:29:52
SRL	0	82	82	0	5	5	0: 0: 0	2: 6: 2	2: 6: 2
SWS	0	185	185	0	6	6	0: 0: 0	3:10: 6	3:10: 6
TAM	111	116	227	5	6	11	1:27:50	1:12: 7	2:39:57
USGS	0	3	3	0	1	1	0: 0: 0	0: 9:43	0: 9:43
VPH	0	2	2	0	1	1	0: 0: 0	0: 0:38	0: 0:38
VPP	0	21	21	0	2	2	0: 0: 0	0: 4: 6	0: 4: 6

WPGU	0	6	6	0	1	1	0: 0: 0	0: 4:33	0: 4:33
ZOOL	9	16	25	1	3	4	0: 2:55	0:40:49	0:43:44
SUBTOTAL	11262	6774	18036	99	250	349	135: 7:24	124:15:42	259:23: 6
DCSSYS[3]	0	3558	3558	0	25	25	0: 0: 0	112:30:16	112:30:16
OVRHED[4]	0	4	4	0	1	1	0: 0: 0	13: 1:11	13: 1:11
REFUND[5]	0	4	4	0	1	1	0: 0: 0	0: 3:15	0: 3:15
SSUAD[6]	0	67	67	0	1	1	0: 0: 0	0:50:20	0:50:20
XDCS[7]	0	509	509	0	2	2	0: 0: 0	14:26:14	14:26:14
XMAINT[8]	0	8	8	0	4	4	0: 0: 0	67: 7:19	67: 7:19
XSSS[9]	0	406	406	0	1	1	0: 0: 0	2:26:11	2:26:11
TOTAL	11262	11330	22592	99	285	384	135: 7:24	334:40:28	469:47:52

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

IBM 1800 TABLE III JAN., 1969

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 1800 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
CE	0	34	34	0	1	1	0: 0: 0	2: 8:14	2: 8:14
DCS	45	0	45	1	0	1	0:32:17	0: 0: 0	0:32:17
EE	0	22	22	0	1	1	0: 0: 0	2:39:37	2:39:37
VPP	0	4	4	0	1	1	0: 0: 0	0: 9:19	0: 9:19
SUBTOTAL	45	60	105	1	3	4	0:32:17	4:57:10	5:29:27
DCSSYS[3]	0	167	167	0	4	4	0: 0: 0	16:23:59	16:23:59
OVRHED[4]	0	0	0	0	1	1	0: 0: 0	1: 8:16	1: 8:16
XSSS[5]	0	0	0	0	1	1	0: 0: 0	0: 0: 0	0: 0: 0
TOTAL	45	227	272	1	9	10	0:32:17	22:29:25	23: 1:42

1 See list of departmental codes following

2 Training and Education

3 System Improvement and Modifications

4 System Use in Excess of User Estimated Usage

5 Special Short Shots

Table I - IBM 360/20

Summary of Use

February, 1969

Unscheduled Engineering		14:59
Scheduled Engineering		8:34
Maintenance		4:09
Production		247:47
Idle		190:16
	Total	465:45

Table II - IBM 360/20

Summary of Machine Errors

February, 1969

2560 MFCM		4
2203 Printer		3
	Total	7

Table I - IBM 360/50-75

Summary of Use

February, 1969

Scheduled Engineering	34:05:00		
Unscheduled Engineering	7:00:00		
Air Conditioning	35:00		
		Subtotal	41:40:00
Total Use			
Training and Education		120:42:39	
System Improvement and Modifications		72:11:52	
System Updating		37:05:26	
University Administrative Overhead Use		2:12:27	
Overhead		6:27:20	
Refund		10:57:32	
Customer Use			
In System	175:52:27		
Special Short Shots	3:03:37		
Customer Use Total		178:56:04	
		Total Use	428:33:20
		Total Time	470:13:20

Table II - IBM 360/50-75

Summary of Errors

February, 1969

75 CPU	1
Total	1

IBM 360/75 TABLE III FEB., 1969

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 360/75 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
AAE	946	231	1177	8	6	14	6:53:11	6: 5:26	12:58:37
ACCY	682	11	693	2	1	3	1:49:33	0:12: 2	2: 1:35
AGE	272	119	391	6	6	12	3:54:37	0:46:35	4:41:12
AGEC	0	223	223	0	11	11	0: 0: 0	5:23:16	5:23:16
AGRON	16	250	266	1	4	5	0: 3:23	1:10:18	1:13:41
ANS	0	2	2	0	1	1	0: 0: 0	0: 0:16	0: 0:16
ARCH	323	0	323	2	0	2	1:53:38	0: 0: 0	1:53:38
ASTR	0	88	88	0	8	8	0: 0: 0	1:22:58	1:22:58
BADM	385	28	413	3	1	4	6: 8:59	0:30:57	6:39:56
BECBSR	0	15	15	0	1	1	0: 0: 0	0: 9:28	0: 9:28
BINRES	0	6	6	0	2	2	0: 0: 0	0: 2: 5	0: 2: 5
CDA	0	3	3	0	1	1	0: 0: 0	0: 4:54	0: 4:54
CE	1144	1136	2280	11	49	60	9:49: 1	27:25:38	37:14:39
CHE	90	1012	1102	5	27	32	1:15:49	17:22:26	18:38:15
CRC	0	50	50	0	1	1	0: 0: 0	0:22:57	0:22:57
CSL	0	147	147	0	2	2	0: 0: 0	2:31:55	2:31:55
DCS	10768	314	11082	13	12	25	65:24:44	6: 2:50	71:27:34
DS	0	47	47	0	2	2	0: 0: 0	0:31:21	0:31:21
ECON	26	33	59	4	3	7	0:22: 2	3: 8:31	3:30:33
ED	5	50	55	1	2	3	0: 0:28	0:18:36	0:19: 4
EDADM	0	34	34	0	1	1	0: 0: 0	1:57:16	1:57:16
EDPSY	39	0	39	1	0	1	0: 4:49	0: 0: 0	0: 4:49
EE	905	653	1558	13	27	40	7:14:28	9:30:29	16:44:57
ENGADM	0	159	159	0	2	2	0: 0: 0	2:38:35	2:38:35
ENGCST	0	24	24	0	1	1	0: 0: 0	0:16:42	0:16:42
ENGH	98	0	98	1	0	1	0:28: 2	0: 0: 0	0:28: 2
ENGRDV	0	2	2	0	1	1	0: 0: 0	0: 0:41	0: 0:41
FIN	19	0	19	1	0	1	1: 9:56	0: 0: 0	1: 9:56
FT	0	10	10	0	2	2	0: 0: 0	0: 5:17	0: 5:17
GENE	298	8	306	5	1	6	1:41:35	0: 2:45	1:44:20
GEOG	0	4	4	0	1	1	0: 0: 0	0: 0:27	0: 0:27
GEOL	82	264	346	2	3	5	1:14: 9	7: 1:41	8:15:50
HONORS	0	5	5	0	1	1	0: 0: 0	0: 0:41	0: 0:41
HORT	0	3	3	0	1	1	0: 0: 0	0: 0:33	0: 0:33
ICR	0	46	46	0	2	2	0: 0: 0	0:27:42	0:27:42
IE	1	0	1	1	0	1	0: 0:10	0: 0: 0	0: 0:10
ILLCF	0	2	2	0	1	1	0: 0: 0	0: 1:16	0: 1:16
ILLDMH	0	162	162	0	1	1	0: 0: 0	5:14:10	5:14:10
INADM	0	46	46	0	1	1	0: 0: 0	0:46:41	0:46:41
MATH	0	116	116	0	5	5	0: 0: 0	1:20:15	1:20:15
MATRL	0	648	648	0	28	28	0: 0: 0	9:50: 8	9:50: 8
MCBIO	0	3	3	0	1	1	0: 0: 0	0: 1: 8	0: 1: 8

ME	1229	681	1910	17	12	29	8: 6:39	15:22: 0	23:28:39
MKTG	0	10	10	0	1	1	0: 0: 0	0: 2:15	0: 2:15
MMPE	0	32	32	0	2	2	0: 0: 0	2:22:25	2:22:25
MUSIC	11	0	11	1	0	1	0: 3:21	0: 0: 0	0: 3:21
NUCE	47	235	282	4	10	14	0:14: 9	2:23:32	2:37:41
OIR	0	250	250	0	1	1	0: 0: 0	1:40:52	1:40:52
ORME	0	5	5	0	1	1	0: 0: 0	0: 3:37	0: 3:37
PHYB	0	72	72	0	2	2	0: 0: 0	2:56:44	2:56:44
PHYCS	74	705	779	2	18	20	0:16:30	7:44: 9	8: 0:39
PHYSL	0	24	24	0	1	1	0: 0: 0	0: 7:54	0: 7:54
PHYX	0	507	507	0	27	27	0: 0: 0	18:13:31	18:13:31
POLS	3	30	33	1	3	4	0: 1:10	0:31:27	0:32:37
PSYCH	26	130	156	1	5	6	0:16: 4	1:35:47	1:51:51
REC	0	8	8	0	1	1	0: 0: 0	0: 9:13	0: 9:13
SCONS	0	33	33	0	1	1	0: 0: 0	0:19:47	0:19:47
SGS	0	149	149	0	2	2	0: 0: 0	1: 5:44	1: 5:44
SRL	0	96	96	0	4	4	0: 0: 0	2: 6:56	2: 6:56
SWS	0	284	284	0	10	10	0: 0: 0	2:20: 0	2:20: 0
TAM	304	223	527	6	13	19	2:16:12	3: 2:51	5:19: 3
VCM	0	7	7	0	1	1	0: 0: 0	0: 8:10	0: 8:10
VPH	0	12	12	0	1	1	0: 0: 0	0: 7:20	0: 7:20
VPP	0	65	65	0	2	2	0: 0: 0	0:16: 2	0:16: 2
WPGU	0	39	39	0	2	2	0: 0: 0	0:12:41	0:12:41
ZOOL	0	45	45	0	3	3	0: 0: 0	0:10:34	0:10:34
SUBTOTAL	17793	9596	27389	112	343	455	120:42:39	175:52:27	296:35: 6
DCSSYS[3]	0	3956	3956	0	26	26	0: 0: 0	72:11:52	72:11:52
OVRHED[4]	0	4	4	0	1	1	0: 0: 0	6:27:20	6:27:20
REFUND[5]	0	331	331	0	2	2	0: 0: 0	10:57:32	10:57:32
UADP[6]	0	112	112	0	2	2	0: 0: 0	2:12:27	2:12:27
XDCS[7]	0	362	362	0	2	2	0: 0: 0	37: 5:26	37: 5:26
XMAINT[8]	0	0	0	0	3	3	0: 0: 0	41:40: 0	41:40: 0
XSSS[9]	0	591	591	0	1	1	0: 0: 0	3: 3:37	3: 3:37
TOTAL	17793	14952	32745	112	380	492	120:42:39	349:30:41	470:13:20

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

IBM 1800 TABLE III FEB., 1969

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 1800 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
AGE	0	5	5	0	1	1	0: 0: 0	0: 5:19	0: 5:19
CE	0	20	20	0	1	1	0: 0: 0	1:19: 6	1:19: 6
EE	11	5	16	1	2	3	0: 6:41	0: 3:43	0:10:24
VPP	0	20	20	0	1	1	0: 0: 0	2:41: 1	2:41: 1
SUBTOTAL[3]	11	50	61	1	5	6	0: 6:41	4: 8: 8	4:14:49
DCSSYS[4]	0	98	98	0	6	6	0: 0: 0	1: 5:11	1: 5:11
OVRHED[5]	0	0	0	0	1	1	0: 0: 0	1:59:29	1:59:29
REFUND[6]	0	8	8	0	1	1	0: 0: 0	1: 3: 5	1: 3: 5
XSSS[7]	0	0	0	0	1	1	0: 0: 0	0: 0: 0	0: 0: 0
TOTAL	11	156	167	1	14	15	0: 6:41	8:15:53	8:22:34

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 Special Short Shots

Table I - IBM 360/20

Summary of Use

March, 1969

Scheduled Engineering		8:11
Unscheduled Engineering		4:21
Maintenance		4:11
Production		298:47
Air Conditioning		15:35
Idle		166:40
	Total	497:45

Table II - IBM 360/20

Summary of Machine Errors

March, 1969

2560 MFCM		4
	Total	4

Table I - IBM 360/50-75

Summary of Use

March, 1969

Scheduled Engineering		27:56:39	
Unscheduled Engineering		26:05:00	
Machine Maintenance		:29	
		Subtotal	54:02:08
Total Use			
Training and Education		188:37:31	
System Improvement and Modifications		103:55:44	
System Updating		29:33:21	
University Administrative Overhead Use		1:06:16	
Overhead		10:38:53	
Refund		7:47:00	
Customer Use			
In System	159:11:40		
Special Short Shots	2:38:36		
Customer Use Total		161:50:16	
		Total Use	503:29:01
		Total Time	557:31:09

Table II - IBM 360/50-75

Summary of Errors

March, 1969

75 CPU	2
50 CPU	3
1052 Console Typewriter	1
Total	6

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 360/75 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
AAE	834	242	1076	9	6	15	6:11:27	5: 0:14	11:11:41
ACCY	619	21	640	1	1	2	2:31:30	0:33: 9	3: 4:39
AGE	329	155	484	5	7	12	4:46: 2	1: 7:57	5:53:59
AGEC	3	100	103	1	9	10	0: 1:34	3:17:19	3:18:53
AGRON	13	318	331	1	4	5	0: 3:50	1:45:54	1:49:44
ANS	0	28	28	0	1	1	0: 0: 0	0: 7:32	0: 7:32
ARCH	1194	7	1201	2	1	3	10: 9:38	0: 4:24	10:14: 2
ASTR	0	73	73	0	7	7	0: 0: 0	1:35:23	1:35:23
BADM	354	48	402	3	2	5	6:47: 3	0:19:12	6:59:15
BCMPL	0	22	22	0	1	1	0: 0: 0	0: 2:53	0: 2:53
BECBSR	0	66	66	0	1	1	0: 0: 0	0:32:15	0:32:15
CDA	0	21	21	0	1	1	0: 0: 0	0: 4: 9	0: 4: 9
CE	1353	1071	2424	13	55	68	12:30:35	22:11:52	34:42:27
CHE	224	1011	1235	5	32	37	1:55:13	16:46:28	18:41:41
CRC	0	42	42	0	2	2	0: 0: 0	0:14:37	0:14:37
CSL	0	88	88	0	2	2	0: 0: 0	1:14:47	1:14:47
DCS	12061	479	1254.	15	10	25	78:43:34	9: 3:50	87:47:24
DS	0	73	73	0	2	2	0: 0: 0	0:59:30	0:59:30
ECON	246	21	267	4	3	7	5:38:18	2:36:10	8:14:28
ED	40	65	105	3	5	8	0:10: 8	0:45:17	0:55:25
EDADM	0	52	52	0	1	1	0: 0: 0	1:45:12	1:45:12
EDPSY	367	0	367	2	0	2	0:47:54	0: 0: 0	0:47:54
EE	3136	636	3772	17	34	51	20:33:16	6: 9:19	26:42:35
ENGADM	0	112	112	0	1	1	0: 0: 0	2:44:24	2:44:24
ENGCST	0	37	37	0	1	1	0: 0: 0	0:29:17	0:29:17
ENGH	257	0	257	1	0	1	1:14:47	0: 0: 0	1:14:47
ENGRDV	0	3	3	0	1	1	0: 0: 0	0: 0:42	0: 0:42
FIN	21	17	38	2	1	3	0:42:28	0: 6:21	0:48:49
FT	0	1	1	0	1	1	0: 0: 0	0: 0:37	0: 0:37
GENE	671	9	680	7	1	8	2:57:26	0: 2:24	2:59:50
GEOL	154	204	358	2	3	5	1:52:22	3:26:27	5:18:49
GSA	0	3	3	0	1	1	0: 0: 0	0: 9:33	0: 9:33
HED	0	5	5	0	1	1	0: 0: 0	0: 5:54	0: 5:54
HORT	0	2	2	0	1	1	0: 0: 0	0: 0:36	0: 0:36
ICR	0	109	109	0	3	3	0: 0: 0	1: 1:13	1: 1:13
ILLDMH	0	172	172	0	1	1	0: 0: 0	9:17:12	9:17:12
INADM	0	83	83	0	2	2	0: 0: 0	1:16:52	1:16:52
MATH	0	126	126	0	5	5	0: 0: 0	2:53:45	2:53:45
MATRL	0	563	563	0	28	28	0: 0: 0	6:21:58	6:21:58
MCBIO	0	11	11	0	3	3	0: 0: 0	0: 4:46	0: 4:46
ME	2459	695	3154	22	14	36	18:19:59	8:23:50	26:43:49
MKTG	0	17	17	0	1	1	0: 0: 0	0: 7:39	0: 7:39

MMPE	0	59	59	0	1	1	0: 0: 0	0:58: 4	0:58: 4
MUSIC	127	0	127	2	0	2	0:58:17	0: 0: 0	0:58:17
NUCE	246	277	523	4	11	15	3:43:1[illegible]	3:36:19	7:19:29
OIR	0	195	195	0	1	1	0: 0: 0	2:21:38	2:21:38
ORME	0	1	1	0	1	1	0: 0: 0	0: 0:13	0: 0:13
PHYB	0	37	37	0	3	3	0: 0: 0	0:22:26	0:22:26
PHYCS	91	647	738	3	16	19	0:31:46	10: 6:12	10:37:58
PHYSL	0	30	30	0	2	2	0: 0: 0	0: 7:58	0: 7:58
PHYX	0	598	598	0	10	10	0: 0: 0	15:32:20	15:32:20
POLS	42	14	56	1	3	4	0:39:54	0:10:19	0:50:13
PROVST	0	5	5	0	1	1	0: 0: 0	0: 2:21	0: 2:21
PSYCH	180	105	285	2	7	9	1:56:57	1: 8:30	3: 5:27
REC	0	31	31	0	2	2	0: 0: 0	0:14:45	0:14:45
SCONS	0	42	42	0	1	1	0: 0: 0	0:23:47	0:23:47
SGS	0	112	112	0	3	3	0: 0: 0	1:19:35	1:19:35
SRL	0	56	56	0	4	4	0: 0: 0	0:47:19	0:47:19
SWS	0	479	479	0	10	10	0: 0: 0	4:12:38	4:12:38
TAM	809	346	1155	8	14	22	4:57:23	3:35:27	8:32:50
UOSCR	0	4	4	0	1	1	0: 0: 0	0: 1:54	0: 1:54
VPH	0	3	3	0	1	1	0: 0: 0	0: 0:53	0: 0:53
VPP	0	134	134	0	2	2	0: 0: 0	0:35:46	0:35:46
WPGU	0	6	6	0	1	1	0: 0: 0	0: 5:40	0: 5:40
ZOOL	0	70	70	0	4	4	0: 0: 0	0:36:43	0:36:43
SUBTOTAL	25830	10053	35883	135	355	490	188:37:31	159:11:40	347:49:11
DCSSYS[3]	0	3899	3899	0	24	24	0: 0: 0	103:55:44	103:55:44
OVRHED[4]	0	7	7	0	1	1	0: 0: 0	10:38:53	10:38:53
REFUND[5]	0	420	420	0	2	2	0: 0: 0	7:47: 0	7:47: 0
UADP[6]	0	69	69	0	1	1	0: 0: 0	1: 6:16	1: 6:16
XDCS[7]	0	54	54	0	2	2	0: 0: 0	29:33:21	29:33:21
XMAINT[8]	0	15	15	0	3	3	0: 0: 0	54: 2: 8	54: 2: 8
XSSS[9]	0	544	544	0	1	1	0: 0: 0	2:38:36	2:38:36
TOTAL	25830	15061	40891	135	389	524	188:37:31	368:53:38	557:31: 9

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

IBM 360/75 TABLE III 1ST QTR., 1969

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 360/75 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
AAE	2267	752	3019	23	18	41	17:10:50	16:12:14	33:23: 4
ACCY	1366	45	1411	4	3	7	4:50:35	1: 0: 1	5:50:36
AGE	739	323	1062	16	16	32	11: 0:41	2:17:31	13:18:12
AGEC	42	467	509	2	30	32	0:24:46	13:35: 8	14: 0:54
AGRON	367	758	1125	4	14	18	2:14: 0	4: 8:47	6:22:47
ANS	0	41	41	0	4	4	0: 0: 0	0: 9:48	0: 9:48
ARCH	1676	7	1683	7	1	8	13:38:28	0: 4:24	13:42:52
ASTR	0	209	209	0	20	20	0: 0: 0	4: 7:11	4: 7:11
BADM	739	76	815	6	3	9	12:49: 2	0:50: 9	13:39:11
BCMPL	0	22	22	0	1	1	0: 0: 0	0: 2:53	0: 2:53
BECBSR	0	95	95	0	3	3	0: 0: 0	0:53:59	0:53:59
BINRES	0	9	9	0	3	3	0: 0: 0	0:11:46	0:11:46
CDA	0	25	25	0	3	3	0: 0: 0	0:10:29	0:10:29
CE	3312	3031	6343	42	146	188	33:41: 8	69:57: 5	103:39:13
CHE	525	2757	3282	16	83	99	7:55: 3	47:59: 0	55:54: 3
CRC	0	115	115	0	4	4	0: 0: 0	0:45:52	0:45:52
CSL	0	283	283	0	6	6	0: 0: 0	4: 6:46	4: 6:46
DCS	28175	1023	29198	46	34	80	215:11:12	22:20:41	237:31:53
DS	0	190	190	0	6	6	0: 0: 0	2:17:35	2:17:35
ECON	350	58	408	9	8	17	6:50: 8	5:53:13	12:43:21
ED	52	142	194	5	8	13	0:15:23	1:15:39	1:31: 2
EDADM	0	120	120	0	3	3	0: 0: 0	4:28:48	4:28:48
EDPSY	435	0	435	6	0	6	0:57:29	0: 0: 0	0:57:29
EE	5049	1756	6805	45	87	132	41:17:11	22:43:16	64: 0:27
ENGADM	0	402	402	0	5	5	0: 0: 0	7: 2:33	7: 2:33
ENGCST	0	93	93	0	3	3	0: 0: 0	1:36:48	1:36:48
ENGH	665	0	665	3	0	3	2:55:14	0: 0: 0	2:55:14
ENGRDV	0	6	6	0	3	3	0: 0: 0	0: 1:49	0: 1:49
FIN	53	47	100	4	2	6	2: 5:37	0:22:19	2:27:56
FT	0	37	37	0	6	6	0: 0: 0	0:15:38	0:15:38
GENE	1305	17	1322	16	2	18	6:48: 9	0: 5: 9	6:53:18
GEOG	0	16	16	0	3	3	0: 0: 0	0: 3:56	0: 3:56
GEOL	396	638	1034	7	9	16	5:20:13	13:28:48	18:49: 1
GSA	0	3	3	0	1	1	0: 0: 0	0: 9:33	0: 9:33
GSBA	335	0	335	2	0	2	6:37:15	0: 0: 0	6:37:15
HED	0	5	5	0	1	1	0: 0: 0	0: 5:54	0: 5:54
HONORS	0	5	5	0	1	1	0: 0: 0	0: 0:41	0: 0:41
HORT	0	5	5	0	2	2	0: 0: 0	0: 1: 9	0: 1: 9
ICR	0	211	211	0	7	7	0: 0: 0	1:49:41	1:49:41
IE	93	0	93	3	0	3	1: 1:11	0: 0: 0	1: 1:11
ILLCF	0	2	2	0	1	1	0: 0: 0	0: 1:16	0: 1:16
ILLDMH	0	470	470	0	3	3	0: 0: 0	17:37:48	17:37:48

INADM	0	171	171	0	4	4	0: 0: 0	2:53:46	2:53:46
MATH	0	251	251	0	12	12	0: 0: 0	4:15:22	4:15:22
MATRL	0	1732	1732	0	78	78	0: 0: 0	24:41: 8	24:41: 8
MCBIO	0	22	22	0	5	5	0: 0: 0	0: 8:20	0: 8:20
ME	5280	1690	6970	56	36	92	38:13:19	30:32:16	68:45:35
MKTG	0	45	45	0	4	4	0: 0: 0	0:15:58	0:15:58
MMPE	0	160	160	0	4	4	0: 0: 0	4:43: 3	4:43: 3
MUSIC	247	3	250	4	1	5	2:11:43	0: 1:37	2:13:20
NUCE	324	686	1010	10	32	42	4: 5:20	7:29:27	11:34:47
OIR	0	721	721	0	3	3	0: 0: 0	6:20:39	6:20:39
ORME	0	15	15	0	3	3	0: 0: 0	0: 5:40	0: 5:40
PHYB	0	240	240	0	7	7	0: 0: 0	7:12:45	7:12:45
PHYCS	175	2210	2385	7	48	55	0:51:34	28:22:28	29:14: 2
PHYSL	0	78	78	0	4	4	0: 0: 0	0:25: 3	0:25: 3
PHYX	0	1749	1749	0	63	63	0: 0: 0	53:36:27	53:36:27
POLS	65	97	162	4	9	13	1: 9:28	1:16:12	2:25:40
PROVST	0	5	5	0	1	1	0: 0: 0	0: 2:21	0: 2:21
PSYCH	206	347	553	3	16	19	2:13: 1	4:13:45	6:26:46
REC	0	46	46	0	4	4	0: 0: 0	0:25:45	0:25:45
SCONS	0	146	146	0	3	3	0: 0: 0	1:17:27	1:17:27
SGS	0	381	381	0	7	7	0: 0: 0	2:59: 4	2:59: 4
SRL	0	234	234	0	13	13	0: 0: 0	5: 0:17	5: 0:17
SWS	0	951	951	0	27	27	0: 0: 0	9:43:39	9:43:39
TAM	1349	728	2077	23	37	60	13:13:14	8:11:14	21:24:28
UOSCR	0	4	4	0	1	1	0: 0: 0	0: 1:54	0: 1:54
USGS	0	3	3	0	1	1	0: 0: 0	0: 9:43	0: 9:43
VCM	0	7	7	0	1	1	0: 0: 0	0: 8:10	0: 8:10
VPH	0	33	33	0	4	4	0: 0: 0	0:16:27	0:16:27
VPP	0	220	220	0	6	6	0: 0: 0	0:55:54	0:55:54
WPGU	0	51	51	0	4	4	0: 0: 0	0:22:54	0:22:54
ZOOL	9	133	142	1	11	12	0: 2:55	1:29:13	1:32: 8
SUBTOTAL[3]	55596	27420	83016	374	1002	1376	455: 4: 9	475:54:15	930:58:24
DCSSYS[4]	0	11413	11413	0	75	75	0: 0: 0	288:37:52	288:37:52
OVRHED[5]	0	15	15	0	3	3	0: 0: 0	30: 7:24	30: 7:24
REFUND[6]	0	755	755	0	5	5	0: 0: 0	18:47:47	18:47:47
UADP[7]	0	248	248	0	4	4	0: 0: 0	4: 9: 3	4: 9: 3
XDCS[8]	0	925	925	0	6	6	0: 0: 0	81: 5: 1	81: 5: 1
XMAINT[9]	0	23	23	0	10	10	0: 0: 0	162:49:27	162:49:27
XSSS[10]	0	1541	1541	0	3	3	0: 0: 0	8: 8:24	8: 8:24
TOTAL	55596	42340	97936	374	1108	1482	455: 4: 9	1069:39:13	1524:43:22

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

IBM 18[illegible] TABLE III MAR., 1969

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 180 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
AGE	[illegible]	1	1	[illegible]	1	1	[illegible]	[illegible] 3:36	[illegible] 3:36
CE	[illegible]	1	1		1	1	[illegible]	[illegible] 2	[illegible] 2
DCS	14	[illegible]	14	1	[illegible]	1	[illegible] 2:55	[illegible]	[illegible] 2:55
EE	13	23	36	1	3	4	[illegible] 8	1:16:12	1:46:2
ICR	[illegible]	2	2	[illegible]	1	1	[illegible]	[illegible]	[illegible]
VPP	[illegible]	41	41	[illegible]	2	2	[illegible]	6:40: 8	6:4[illegible]: 8
SUBTOTAL	27	68	95	2	8	10	[illegible]:33: 3	8:36:58	9:10: 1
DCSSYS[3]	[illegible]	64	64	[illegible]	4	4	[illegible]	6:39: 8	6:39: 8
OVRHED[4]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	[illegible]	[illegible]:29	[illegible]:29
REFUND[5]	[illegible]	2	2	[illegible]	1	1	[illegible]	0:35:38	0:35:38
XSSS[6]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	[illegible]	[illegible]	[illegible]
TOTAL	27	134	161	2	15	17	[illegible]:33: 3	15:52:13	16:25:16

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 Special Short Shots

IBM 1800 TABLE III 1ST QTR., 1969

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 1800 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
AGE	0	6	6	0	2	2	0: 0: 0	0: 8:55	0: 8:55
CE	0	55	55	0	3	3	0: 0: 0	4: 3:22	4: 3:22
DCS	59	0	59	2	0	2	0:35:12	0: 0: 0	0:35:12
EE	26	50	76	3	6	9	0:42:24	3:59:32	4:41:56
ICR	0	2	2	0	1	1	0: 0: 0	0: 0: 0	0: 0: 0
VPP	0	65	65	0	4	4	0: 0: 0	9:30:27	9:30:27
SUBTOTAL[3]	85	178	263	5	16	21	1:17:36	17:42:16	18:59:52
DCSSYS[4]	0	329	329	0	14	14	0: 0: 0	24: 8:18	24: 8:18
OVRHED[5]	0	0	0	0	3	3	0: 0: 0	3: 8:14	3: 8:14
REFUND[6]	0	10	10	0	2	2	0: 0: 0	1:38:43	1:38:43
XSSS[7]	0	0	0	0	1	1	0: 0: 0	0: 0: 0	0: 0: 0
TOTAL	85	517	602	5	36	41	1:17:36	46:37:31	47:55: 7

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 Special Short Shots

LIST OF DEPARTMENT CODES

If your department or office does not appear on this list, please write its full name in the department field on the Problem Specification Form even though it will require more than 6 characters.

ACCY	Accountancy
ADMREC	Admissions and Records
ADV	Advertising
AAE	Aeronautical and Astronautical Eng.
AGEC	Agricultural Economics
AGE	Agricultural Engineering
AGREXT	Agricultural Extension
AGRON	Agronomy
ANS	Animal Science
ANTH	Anthropology
ARCH	Architecture
ASTR	Astronomy
BIOPH	Biophysics
BOT	Botany
BCMPL	Bureau of Community Planning
BECBSR	Bureau of Economic Business Research
BEDRES	Bureau of Educational Research
BINRES	Bureau of Institutional Research
BED	Business Education
CZR	Center for Zoonoses Research
CERE	Ceramic Engineering
CPUBS	Champaign Public Schools
CHE	Chemistry and Chemical Engineering
CRC	Children's Research Center
CP	City Planning
CE	Civil Engineering
COMM	Communications
CURLAB	Curriculum Laboratory
DS	Dairy Science
DCS	Department of Computer Science
DGS	Division of General Studies
DUE	Division of University Extension
DOW	Division of Waterways
ECON	Economics
ED	Education
EDPSY	Educational Psychology
EDADM	Educational Admin. and Supervision
EDTEST	Educational Testing
EE	Electrical Engineering
ENGADM	Engineering Administration
ENGCST	Engineering College and Station
ENGH	Engineering Honors Program
ENGLSH	English
ENTOM	Entomology
EDC	Extension Division Counseling
FIN	Finance
FT	Food Science
FOR	Forestry
GENE	General Engineering
GEOG	Geography
GEOL	Geology
GER	German
GSBA	Graduate School of Business Admin.
HED	Health Education
HLTHSV	Health Service
HEC	Home Economics
HONORS	Honors Program
HORT	Horticulture
ILLDMH	Illinois Dept. of Mental Health
INADM	Industrial Administration
IE	Industrial Engineering
IREC	Institute for Researh on Exc. Children
ICR	Institute of Communications Research
IGPA	Institute of Govt. and Public Affairs
ILR	Institute of Labor and Ind. Relations
LIBS	Library Science
LING	Linguistics
MKTG	Marketing
MATRL	Materials Research Laboratory
MATH	Mathematics
ME	Mechanical Engineering
MCBIO	Microbiology
MMPE	Mining, Metallurgy, and Petroleum Eng.
MUSIC	Music
NHS	Natural History Survey
NUCE	Nuclear Engineering
OAC	Office of Agricultural Communication
DNW	Office of the Dean of Women
OIR	Office of Instructional Resources
PEM	PE for Men and Graduate PE
PEW	PE for Women
PHYPLA	Physical Plant
PHYCS	Physics
PHYB	Physics Betatron Laboratory
PHYX	Physics Project X
PHYSL	Physiology and Biophysics
PLPA	Plant Pathology
POLS	Political Science
PROVST	Provost's Office
PSYCH	Psychology
REC	Recreation
SHCBRC	Small Homes Council
SOCW	Social Work
SOC	Sociology
SCONS	Soil Conservation Service
SPED	Special Education
PSDEC	Special Education, Decatur Pub. Schools
SPCH	Speech and Theatre
SGS	State Geological Survey
SWS	State Water Survey
SCS	Student Counseling Service
SRL	Survey Research Laboratory
TAM	Theoretical and Applied Mechanics
USGS	U.S. Geological Service
UNIHI	University High School
UCCTE	Urbana-Champaign Coun. on Teacher Ed.
VMS	Veterinary Medical Science
VMA	Veterinary Medicine Administration
VPH	Veterinary Pathology and Hygiene
VPP	Veterinary Physiology and Pharmacology
VTED	Vocational and Technical Education
WPGU	WPGU Radio Station
ZOOL	Zoology

Chicago Circle

CCCHE	Chemistry
CCDME	Materials Engineering
CCENEN	Energy Engineering
CCPHCS	Physics
CCSOC	Sociology
CCSCS	Student Counseling Service

Medical Center

ORME	Office of Research in Medical Ed.
OT	Occupational Therapy

Ill. State University

ISEDAD	Department of Education Administration

9.3 Research Problem Specifications

During the first quarter of 1969, 136 problem specifications were submitted to the Department for computation on the System/360. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

2108 Education. Personnel Accounting. Accounting routines will be developed to generate various tables involving personnel. (R. E. Williams)

2109 T Materials Research Laboratory. Laser Raman Spectroscopy. Data analysis of Raman scattering from defects in alkali halides and from mixed semiconductors. (M. V. Klein)

2110 State Water Survey. Instantaneous Rainfall Rate. The purpose of this research for the Air Force shall be to define the instantaneous rainfall rate frequencies at a point and along lines from 5 to 50 miles in length. These frequencies will be developed to be representative of stations in the climates of the world, based upon the present state of knowledge and available data. The results will be presented as nomograms of families of curves of instantaneous rates (one-minute accumulations) from 0.01 inch through 5.00 inches versus the ratio of monthly rainfall to the number of rain days per month or some equivalent units. (D.M.A. Jones)

2112 Civil Engineering. Stochastic Analysis of Hydrologic Systems. To solve nonstationary Markov matrices of input rainfall, output runoff, and conceptual watershed storage of a watershed hydrologic system. (V. T. Chow)

2117 Psychology. Investigation of Alternative Compensation Schemes for Industry. Investigation of individual differences through analysis of response characteristics. (Nealey)

2118 Zoology. Selection for Dental Traits in the House Mouse. Artificial selection is being applied to the width of the upper first molars of the house mouse. High, low, and control lines are being maintained. Correlated responses of other dental traits, body weights, and fitness components are being measured. (M. Joan Larson)

2119 Electrical Engineering. CORNAP Network Analysis Program. It is desired that CORNAP be made available to all 360/75 users. It was suggested that this be done by placing the program on a disk under a number with zero time. Users could call the program with their own problem specification number. (T. N. Trick)

2121 T Electrical Engineering. Computation and Interpretation of Holograms. The problem is to simulate on the computer the production and interpretation of holograms. The first aspect of this problem will be to compute the hologram produced by a given object. The second, or inverse problem, will be to evaluate the form of the object or to estimate the currents flowing over it, from the knowledge of a hologram. The mathematical method will feature a new algorithm for taking the Fourier Transform. This algorithm can reduce the number of complex operations (i.e., one complex operation ≡ an addition and a multiplication), needed to Fourier transform a vector X_k, (k = 0, 1, ..., N - 1) from N^2 to N $\log_2$ N. (P. L. Ransom)

2122 T Electrical Engineering. Ionospheric Wave Propagation. Solution of a group of equations which describe the propagation of gravity waves and radio waves in the ionosphere. (Clark)

2123 T Physics. Photodisintegration of He^4 for Gamma Energies from 180 to 340 Mev. The cross section for the photodisintegration of Helium-4 into a proton and a triton was studied over a range of photon energies from 180 Mev. to 320 Mev. using spark chambers and scintillation counters. (S. E. Kiergan)

2126 T Civil Engineering. Seismic Analysis of Piping Systems. Analysis of coupling criteria and definition of input to piping systems housed in an elastic structure. (R. Kassawara)

2127 Geology. Stratigraphic Analysis. Analysis of cycles and periodicities in stratigraphic sequences and investigations into entropy of stratigraphic units as an indicator of environmental conditions during deposition. (Mann)

2128 Geology. Granular Media Calculations. A stable configuration of regular grains in elastic contact is found by minimising the system energy. This configuration is perturbed by applying a shear stress. The stress-strain response is calculated numerically. The calculation then yields the modulus of the system, as well as the losses under alternating stress fields. (Vaisnys)

2129 Mechanical Engineering. Heat Transfer Research. Research concerned with transient radiative transfer and unsteady boundary layer flows. (R. E. Hering)

2130 T Electrical Engineering. Scattering by Two Spheres. Multipole expansion technique of scattering by spheres combined with iteration method of decoupling equations for multipole coefficients. (Y. T. Lo)

2132 T Agricultural Economics. An evaluation of Marketing Carcass, Primal Cuts, and Retail Cuts Beef in the United States. Given a level of supply and a level of demand for beef, carcasses or boxed primal cuts and retails cuts, in each region, the problem is to minimize the total costs of slaughtering, processing, and transportation under the equilibrium restraint that total supply equals total demand. Specifically, the problem is that of determining an optium distribution and pricing system that will maximize returns to the beefpacker and minimize the costs of consumers by considering alternative forms of the beef product subject to a set of constraint conditions. (J. D. Sullivan)

2134 Mining, Metallurgy, and Petrcleum Engineering. Statistical Models of Porous Media. Bifurcating graphs are used to simulate flow of fluids through porous media. Every bifurcating graph is represented by a certain number of ones and zeros. Hence a Monte Carlo technique has to be used to generate these ones and zeros at random and to deduce the physical significance of the graphs. (A. E. Scheidegger)

2135 Survey Research Laboratory. OS/360 - Development Runs. SRL library programs to be run on survey data. (M. F. Uchida)

2136 T Agricultural Economics. Organizational Effects of Alternative Methods of Financing Land Resources. By MPS 360 to run a 20 years multiperiod linear programming model. The objective of this model is to maximize consumption and saving over the planning period subjects to alternatives methods of financing land resource. (Joyce Tsai)

2138 Computer Science. A Generalized Array Language. To design and implement a generalized array type language which would be useful for solving nonlinear problems in the mathematical sciences. (Phillips)

2140 Psychology. Methods to Study Individual and Population Behavior. The research project on methods to study individual and population behavior concentrates on development and trial of theories and procedures for analysis of data on psychological phenomena. Many of the procedures use matrix computations and are related to factor analysis. (Ledyard R. Tucker)

2141 T Psychology. Analysis of SBSGI and NOSIE-30. Multiple analysis by SOUPAC. (Robert Lentz)

2146 T Theoretical and Applied Mechanics. Parametric Response of Orthotropic Plates. Orthotropic plates subjected to parametric loads are investigated for regions of stability. The nonlinear partial differential equations, resulting from consideration of deformations in the middle surface, are solved using a modified Galerkin technique. (Will Carter)

2148 T Electrical Engineering. The Ionospheric F-2 Region Behavior. The continuity equation of the ionizations will be solved simultaneously with the equation of motion of the neutral atmosphere. The effect of the neutral wind will be investigated. (K. C. Yeh)

2150 Agronomy. Multiple Correlation - Yield vs. Temperature and Moisture. Corn and soybean yields from different years and different soils will be correlated with temperature and moisture (rainfall and stored soil moisture). Partial derivatives relating variations in yield to the independent variables will also be solved. The CalComp plotter will be used to graph results. (Runge)

2153 Sociology. Legal Survey Research. The major purpose of this research is to investigate ways in which the burdens of proof applicable in criminal and civil trails can be defined more precisely and more objectively. The scheme proposed in this study requires that a national sample of state and federal judges translate the terms "beyond a reasonable doubt" and "by a preponderance of the evidence" into statistical statements of probability. The judges' quantitative translations would then be compared against those reported by prospective jurors whose names would be obtained from local voters' registration lists. (Rita Simon)

2159 T Mechanical Engineering. Machine Design Gear Research. The phenomena of self-excited and externally excited torsional and axial vibrations are being studied to determine their effects upon instantaneous gear tooth loads and the gear train power transmission efficiency. (R. W. Adkins)

2168 Clark, Dietz, and Associates. Truss Frame Calculations. Truss frame analysis using STRESS. (M. F. Tigrak)

2169 T Materials Research Laboratory. Capacitance vs. Voltage Data Analysis. Least squares polynomial fit to experimental data. (W. Hyatt)

2173 T Electrical Engineering. Numerical Analysis of Integral Equations. The numerical solution of integral equations associated with electromagnetic theory will be attempted. (A. J. Poggio)

2175 T Chemistry and Chemical Engineering. Flow Through Regular Packed Beds. An attempt is made to get some understanding of the local properties of the flow field in a regular packed bed. The digital computer is used to solve numerically the boundary layer equations for flow past an array of spherical particles. Comparison of those results with experimental values would provide the means to assess the possibility to use the computer for the prediction of local and average properties in the packed bed. (Anastas Karabelas)

2176 Civil Engineering. Blast Effects on Underground Structures. Finite difference analog models are to be employed to solve complex problems in wave mechanics. (L. A. Lopez)

2177 Mechanical Engineering. A Study of Supersonic Base Drag Problems. A study is being conducted of the base drag resulting from the interaction between the supersonic freestream and propulsive-nozzle flows. This problem is being analyzed by the Method of Characteristics in conjunction with an approximate treatment of the viscous mixing phenomena. (A. L. Addy)

2178 Civil Engineering. Optimization Course Development. A series of mathematical programming subroutines is to be developed and tested for use by students in a newly developed course, "Optimization Techniques and Applications". (D. M. Brown)

2179 General Engineering. Radon Concentration. This program calculates concentration of either radium 226 or radon 222 adjusted for the activity at the time when sampling was accomplished. (J. E. Pearson)

2181 T Education. Communications as a Factor in Agriculture Business Employment. ANOVA of semantic differential estimation of communications between agriculture business employers, agriculture occupation teachers and twenty-four pupil subgroups. The instrument is the semantic differential with twenty-one concepts of ten-item scales. Sample is 400 pupils, 40 teachers and 40 agricultural business employers. (Vernon)

2182 Veterinary Clinical Medicine. Veterinary Medical Data Program. Data retrieval of all diagnostic and operative procedures as summarized monthly from abstracts of Farm Veterinary Service case records. Monthly patient summaries to be used for research, case studies and departmental reference. (Joyce Phares)

2183 Chemistry and Chemical Engineering. Enzyme Kinetics Fit to Rate Laws. The program will examine raw data from enzyme-catalyzed reactions and will fit these data to rational functions. (W. O. McClure)

2184 Chemistry and Chemical Engineering. Enzyme Kinetics. The program will fit enzyme kinetic data to appropriate rate laws and provide statistical evaluation of the quality of fit. (R. L. Switzer)

2188 T Mechanical Engineering. Operations Research. General problems in operations research, analysis, programming. (L. E. Doyle)

2190 T Agricultural Engineering. Noise Spectral Analysis. Analog to digital conversion of raw fan noise data. Power spectral density analysis of the data will be performed. The noise data will then be incorporated into a dimensional analysis to determine the effects of fan design and operation parameters on fan performance and noise production. (John Hummel)

2191 Computer Science. Stiff Differential Equations. Investigation of techniques for solving "stiff" ordinary differential equations. Specifically, the chemical kinetic equations describing the upper atmosphere will be integrated. (McIntyre)

2195 Mechanical Engineering. Optimization of Mechanical Power Structures. Optimization of basic thermodynamic cycles using numerical methods. (W. L. Hull)

2218 Materials Research Laboratory. Scattering by Vortices. Ultrasonic attenuation in superconductor containing random array of vortices as function of magnetic flux and temperature. (R. M. Cleary)

2222 T Zoology. Molecular Weight Determination by Equilibrium Sedimentation of Two Proteins. The molecular weight of two proteins which have been isolated and purified will be determined by analysis of protein position and concentration in a cell under centrifugal force, in the Beckman Spinco Model E Analytical Ultracentrifuge. The computer is needed to analyse the data from the centrifuge. (Peter Bruns)

2223 T Aeronautical and Astronautical Engineering. Aircraft Structure Synthesis. Computerized synthesis of aircraft design for the purpose of optimizing aircraft structures and performance. (Kraus)

2227 Electrical Engineering. Research on Control Systems and related problems. Various types of problems on research in control systems and related areas. (B.C.Kuo)

2230 T Chemistry. Interferogram Data Reduction. This problem deals with the reduction of interferograms to spectra using the Cooley-Tulsey method of Fourier transformation. Appropriate apodizations and phase corrections are applied where necessary. (Gary Horlick)

2231 Mechanical Engineering. Evaporator Response. Numerical solution of analytical study of dynamic response of a refrigeration evaporator to changes in flow rate of refrigerant. (W. F. Stoecker)

2232 Physics. Mossbauer Analysis. Calculation of Mossbauer spectra and fitting of experimental spectra. (Debrunner)

2237 Mechanical Engineering. Synthesis and Optimization of Non-Involute Gears. Problem involves a study of non-involute gears with the purpose being to develop gears of higher load capacity than those of present. Many types of numerical analyses are required for this study. (A. O. Lebeck)

2238 State Water Survey. Precipitation Modification Study. The purpose of this research proposal is to perform detailed and extensive analyses of rainfall data in the midwestern United States and to use the results of these analyses to establish techniques for the design and evaluation of future weather modification projects, in which the basic purpose is to modify the natural distribution of surface rainfall. (Robert Sinclair)

2244 T Theoretical and Applied Mechanics. Deflection of Curved Beam. The large and small deflections of a curved beam of variable cross section are calculated by successive summation of the deformations of a finite number of sections, each of which is considered to be circular. The beam is loaded by a force and/or a moment at each end. (J. C. McWhorter)

2246 State Water Survey. Sensitivity of Fuze to Rain. Rainfall rates will be determined from digitized raingage traces. The raingage traces were obtained during firing of artillery fuzes through rain in Panama. The average rainfall rate over the distance that the fuze penetrated before detonation will be calculated. (E. A. Mueller)

2248 Electrical Engineering. Ion Beam Sources. Inverted magnetron plasma sources for Ion Beams. (Hendricks)

2249 Electrical Engineering. Liquid Density Measurements. Instrumentation for stream and Lake water density measurement. Results to provide pollution level data. Rapid sampling and data analysis to be employed. (Hendricks)

2262 Chemistry. Stability of Transient Systems. The stability of certain transient fluid systems exhibiting coupled transport processes at the macroscopic level is to be investigated. (R. L. Sani)

2263 Horticulture. Rubus pollen. Statistical evaluation of media used for germination of Rubus pollen in vitro. (Otterbacher)

2264 Civil Engineering. Evaluation of Bridge Deflection Criteria. Evaluate effects of deflection constraints on the optimum proportions, cost, and behavior of steel highway bridges. Object program for a bridge design routine to be used in conjunction with POST POL to be placed on disk. (R. N. Wright)

2271 T Computer Science. Automatic Function Generation. Analysis of automatic function generation algorithms presently being developed. (B. G. Delugish)

2272 T Electrical Engineering. Corrugated Cylindrical Waveguide. Study of the properties of a corrugated cylindrical waveguide. (Lo)

2273 Mathematics. Combinatorial Searches for Block Designs. Substructures are isolated and representatives are formed for each substructure class. The computer is then used to attempt to complete the substructure to a full design. (J. W. Brown)

2274 Mathematics. Group Relator Generation. By random number techniques generate relators as conjugates and products of basic relators. Try to determine groups in which the non-trivial application of this technique yields the minimal length of generated relators and increasing function of the number of relators used. Applications to finding groups with solvable word problems are hoped. (Appel)

2275 Mathematics. Lattice Triple Packing of Spheres in E^3. The problem is to find the minima of certain piece-wise differentiable functions which arise in finding the most economical lattice arrangement of equal spheres in three-space so that no point of space is in more than 3 interiors of spheres. After the computer finds these, I will prove them. (George Barry Purdy)

2280 Institute of Communications Research. Human Judgment. The present studies investigate the parameters of human judgment across a variety of situations. In particular, the variables of interest are: (a) the transsituational generality of preference and similarity judgments; (b) the outside correlates of such judgments; and (c) the isolation and prediction of individual differences in judgment types. Multivariate methods of analysis will be used including factor analysis, multidimensional scaling, canonical prediction, discriminant function analysis, and multivariate analysis of variance. (Wiggins)

2282 Civil Engineering. Properties of Seal Coats and Surface Treatments. Repetitive computations are necessary to determine the void space existing in an aggregate layer as a function of depth within the layer. Statistical analysis of the data obtained is also desired. (Marek)

2283 State Water Survey. Urban Hydrology. The objective of this study is to gain insight into the effects of watershed and rainfall charactertics on runoff from urban areas. It is hoped that through the use of a digital computer, a design methodology for urban storm drainage facilities can be confirmed. (Mike Terstriep)

2285 T Materials Research Laboratory. CO^{59} NMR First Derivative. CO^{59} NMR first derivative plot. (Vernes)

2287 Electrical Engineering. Scattering from Plasma Slabs and Columns. The objective of this program is to study the scattering from plasma slabs and columns with a view to finding the spatial distribution of inhomogeneities in the medium. (B. C. Kuo)

2290 T Electrical Engineering. Thin-film circuit analysis. The object of this work is to derive solutions for the capacitance, charge distribution and other characteristics of a number of microstrip structures. The method employs a matrix or integral formulation and solution of these equations by numerical means. (Snyder)

2292 T Coordinated Science Laboratory. Simulation of an Associative Processor. A model of an associative processor will be simulated in assembler language. (Lipovski)

2293 Agricultural Engineering. Analysis of Swine Waste Treatment. Data obtained from laboratory and field installations will be analysed and plotted by the Cal Comp plotter in order to evaluate the performance of various swine waste treatment schemes. (Don D. Jones)

2295 T Agricultural Economics. Length of Corn Harvest; Selection of Harvest System. Several data analysing programs will be run to prepare input data for a cost minimising Linear Programming model designed to select harvest machine systems. The LP model will require a mixed integer type solution (one is soon to be available). A series of parametric solutions will be needed. Use of a quadratic objective function may also be needed. (Robert Batterham)

2296 Nuclear Engineering. Laser Coupling. This research is concerned with a study of nuclear reactor-laser coupling. Detailed calculations of the properties of radiation induced plasmas are required, and some data analysis will also be done. Standard numerical methods are used. (G.H. Miley)

2300 T Chemistry. Boiling Performance of Transverse Fins. The object of the problem is to generate boiling curves for transverse fins. Agreement is sought between the generated solution and an experimental curve for a specific case. Other curves are then to be calculated by varying the fin metal, boiling liquid, and geometric factors. (D. L. Bondurant)

2307 Nuclear Engineering. Radiation Plasmas. This study is concerned with an investigation of the properties of radiation induced plasmas. Standard numerical methods are used to solve some simple plasma models. (Miley)

2308 Electrical Engineering. Optimization Studies on Active Antennas. A multi-variable, evaluation function will be established for transmitting and receiving, active antennas. The computer will be used to find a set of variables which minimizes this evaluation function. (Ore-Renken)

2312 T Physics. Energy-Energy Correlation Function. The program will calculate the four-point (energy-energy) correlation function of a high-temperature ising model, with the aim of finding the critical exponents of the model and checking the scaling laws. (R. Rutherford)

2314 Psychology. Vigilance. Research to investigate the effect of decision processes on simple monitoring performance. (Williges)

2320 Computer Science. Music Analysis by Computer. Music is to be read into the 1800 using the A/D converter, and reproduced using the D/A converter. (Friedman)

2322 T Materials Research Laboratory. Laser Scattering and Fluorescence. Theory and Data reduction for Laser scattering and fluorescence experiments. (Stantonstacy)

2323 T Nuclear Engineering. Lasers. LASERS -II OPTICAL SPECTRA MODELS. Models predicting the optical spectra excited by nuclear radiation will be tested and compared to experimental observations. Models for the slowing down spectra will be developed and tested for use in the balance for excited states. (Paul E. Thiess)

2325 Economics. Hong Kong Time Series Study. (1) Hong Kong's trade data will be studied using decomposition of time series. To determine the pattern and the stability of the seasonal variations, analysis of variance and simple regression techniques will be used. (2) The trade data together with other available macroeconomic data and some prior information about Hong Kong will be used to construct a model of the economy. The solution of the parameters in the model will involve quadratic programming. (Patrick Yeung)

2330 T Nuclear Engineering. The Influence of Hydrodynamic Models on Power Level and Temperature Calculations for Mild Transients in Fast Reactors. The object of this study will be to determine the effect of various flow models on the predicted power level, fuel temperature and coolant temperature responses during mild transients in sodium-cooled fast reactors. To study this effect, computational methods which account for temperature feedback in the fuel and the coolant will be developed for the analysis of mild excursions.

The selection of a flow model for the design analysis of a reactor system is based in part upon coolant properties and characteristics of the system denoted by Reynolds and Peclet numbers. However, the interaction of this selection in the subsequent neutronics and temperature calculations has not been determined.

Four flow models will be studied: bulk flow, slug flow, laminar flow and turbulent flow. In the first model, a bulk mean temperature is determined in the coolant while in the last three models, detailed temperature profiles will be calculated. Parameters will be defined to make comparisons of the effects of the four flow models.

The computational approach will be to reduce by means of Hankel transforms the partial differential equations which govern the neutron flux and the temperatures to sets of ordinary differential equations. These equations will then be solved numerically by Lie series. (Peddicord)

2331 Business Administration. Factor Analysis of Performance Ratings. The problem is aimed at determining the most relevant variables in a collection of performance rating parameters in order to isolate certain key elements. (K.M. Rowland)

2335 T Electrical Engineering. Time Analysis of Speech. An attempt will be made to analyze certain of the parameters of the speech waveform, using a differential equation model for the vocal apparatus. Of special interest will be the properties of the vocal cords. (J. W. Atwood)

2338 T Materials Research Laboratory. X-ray Structures of Molecular Crystals. Determination of the structure of three organic molecular crystals in the solid state by single crystals in the solid state by single crystal X-ray techniques. (D. Y. Curtin)

2340 Aeronautical and Astronautical Engineering. Density and Distribution Function Errors. Numerical evaluation of the error that results when the detector signal in a molecular beam experiment is assumed equal to a certain average of the distribution function. (Sentman)

2341 Business Administration. Purchasing Behavior Predicted By N-Ach. The relationship between levels of need for achievement and present and desired inventory of goods and services. (David M. Gardner)

2343 T Electrical Engineering. Speech Synthesis. Various problems in speech synthesis are being studied. In particular, an attempt is being made to write equations for speech-like events using exponentially damped sinusoids. (M. Hoffman)

2344 T Electrical Engineering. Speech Analysis. An analysis of the output pulse trains produced by a non-linear adaptive speech processor, and of the patterns existing therein. (J. Cohen)

2345 T Physiology. Curve-fitting for Muscle Mechanics. I plan to use this computer time to fit experimental tension-length and force-velocity data from mechanical measurements of non-striated muscle to characteristic exponential and hyperbolic equations and to determine the goodness of fit. (Meiss)

2346 T Electrical Engineering. Power System Analysis. Power System Analysis using Load Flow, Fault Studies, and Stability Studies. (Edwin T. Bartlett)

2347 Graduate Student Association. Voter List Preparation. A list of names and addresses of students will be sorted by address to yield street lists for the purpose of voter registration. (Morrison)

2348 T Chemistry. Solid-State Rearrangement of Oxime Picryl Ethers. The research involves the crystal structure analyses of several benzophenone oxime picryl ethers. In the method, the computer is used for computation of Fourier maps, structure-factor calculations, and least-squares refinement. (D.Y. Curtin)

2351 T Nuclear Engineering. Solution of Transient Heat Diffusion Eqn with Non-Uniform Source Term. Numerical solution of the transient heat diffusion equation for the spacial distribution of the heat source causing the measured temperature transient. (Weaver)

2355 Finance. Life Insurance Company-Mutual Fund Combination Study. This study is examining the characteristics of life insurance companies that have entered the mutual fund field. Analysis of variance will be used to test the hypothesis that there is a difference in the characteristics of life companies that (1) start a mutual fund, (2) purchase a mutual fund, (3) affiliate with a mutual fund. The characteristics included are: (a) rate of growth of assets, (b) rate of growth of ordinary life and endowment business, (c) new insurance written, and (d) rate of return in the common stock portfolio. (James A. Gentry)

2356 T Electrical Engineering. Neurophysiological Display Processing. In processing neuro-physiological data it is common to monitor the events on an oscilloscope as they occur, but to record them on film or analog tape for later hard copying. It is very difficult to detect patterns or interrelationships extending over more than a few spikes by monitoring on the oscilloscope. And even with a hard copy of the data, patterns are not obvious. The purpose of this project will be to process and display the spike trains in such a way that temporal patterns become easier to observe in real time on an oscilloscope. Data will be presented to the 1800 from analog tape and the results displayed by analog output to drive an oscilloscope. (Kenneth J. Kokjer)

2357 Electrical Engineering. Computer Services. For using the various computer services available through DCS. (E.W. Ernst)

2358 T Chemistry. Electroanalytical studies of Oxidation Reduction Mechanisms. Electroanalytical techniques are applied to chemical systems in both aqueous and molten salt solvents for the purpose of investigating oxidation-reduction mechanisms. (H. A. Laitinen)

2359 T Political Science. Cohort Analysis of Political Opinions. A 20-year time series analysis of age cohorts with respect to selected political opinions using survey data. (Klecka)

2360 Political Science. Guatemala Study. Statistical analysis of survey data collected in Guatemala. (Meehan)

2361 Sociology. Rural Industrialization Project. The Rural Industrialization (Hennepin) Project is concerned with measuring social change in a rural region due to the location of a large steel plant in the area. The basic data that is being analyzed was obtained from two surveys of a panel of heads of households. These surveys were carried out in the area surrounding the steel plant and also in another comparable area which serves as a control area. Use of the control area makes it possible to document whether any social change observed is due to the effects of industrialization or to outside factors that are operating on both areas. The use of the computer is necessary because of the large number of interviews and variables measured. Extensive use will be made of SOUPAC programs because much of the analysis will be concerned with correlations, frequency counts and factor analysis. (Tex Summers)

2362 Physics. Approximate Triangle Amplitude. An approximate form to the triangle amplitude in three-body decays is suggested. Verification of the validity of the approximation (involving integrations) is desired. (Anna J. Martin)

2363 T Civil Engineering. Bolted Connections - Prying Action. Finite element analysis of bolted tee-connections under tensile loading. (Nair)

2364 Physiology. Blood-Tissue Exchange. Data is analyzed from indicator - dilution experiments in the circulation of dogs. Models of blood-tissue exchange are simulated. (E. S. Kirk)

2365 Materials Research Laboratory. Crystal Growth Rates. This problem pertains to a project concerned with the growth of crystals in glass systems, and involves fitting a theoretical curve to the data. The data are experimental measurements of the growth rate of lead borate crystals from a melt at various temperatures below that of the liquidus. (C. G. Bergeron)

2366 T Chemistry. Stability of a Reacting Fluid Layer. This is to replace PS number 7N099. (R. A. Schmitz)

2367 T Economics. Housing Rehabilitation Study. Correlation and regression analysis of data on costs of residential rehabilitation. (Boland)

2370 T Agricultural Economics. L. P. Mexican Irrigation. Linear programming analysis of irrigation in N. W. Mexico using parametric pricing and alternative objective functions. (E. B. Erickson)

2372 T Agricultural Economics. Economic Effects of Private Irrigation in Uttar Pradesh. Many farmers in Western Uttar Pradesh have recently installed power-driven pumps to provide their own source of irrigation water. The problem is to use linear programming to estimate the future effects of this new technology, combined with chemical fertilizers and new seed varieties on cropping pattern, total crop output and on labor and bullock power use on representative farms in the area under conditions of varying product prices and varying levels of input use. (I. R. Wills)

2373 Agricultural Engineering. Weather Tape Transfer. Transfer of data in tape-to-tape. Change in mode and density. Program used to determine superimposed characters. (Bloome)

2374 Mechanical Engineering. Thermal Systems. Optimization, simulatio and heat transfer problems in thermal systems. (W. F. Stoecker)

2380 T Mechanical Engineering. Transient Diffusion Flame Phenomena. The computer will be used for data reduction and analysis of combustion phenomena. Normal machine functions will be employed and no special subroutines will be required except those built into the machine. (E. K. Buchholz)

2382 Civil Engineering. Residual Stress of Welded Beams. Analysis of residual stresses due to welding in the web of a beam with stiffeners. Also analysis of web deflections in a thin webbed girder with stiffeners. (Robert Dolmetsch)

2384 T Economics. On Combining Cross-Section and Time Series Data. A Monte Carlo study comparing the various estimators which use both sources of information. (Johnson)

2385 T Aeronautical and Astronautical Engineering. Transverse Waves Behind a "Cylindrical" Detonation Shock. A Runge-Kutta technique is used to solve two sets of related first order ordinary differential equations. The first set being derivatives of space coordinates w.r.t. time, and the second set being derivatives of variables of the first set w.r.t. space. Starting conditions for variables in the first set are known. (Might)

2386 T Educational Psychology. Analysis of Critical Moments in Counseling. Responses of different groups of educators to simulated problems on videotape are to be analyzed and correlated with personality and other variables, including teaching techniques. (Peterson-Thayer)

2387 State Water Survey. Crop-Hail Research. The research is directed at various studies of surface hail data and historical hail data from Illinois. Particular emphasis is on the use of infrared film in the detection and measurement of hail damage to crops. (Robert Sinclair)

2388 State Water Survey. Radar-Rainfall Comparisons. Data from a network of 196 raingages will be compared statistically with data from an automatic radar data processor. (E. A. Mueller)

2390 Computer Science. Lattice Dynamics. The thermal properties of one - and two- dimensional nonlinear crystal models will be studied. (J. R. Pasta)

2392 T Electrical Engineering. Read Interferometer Tape. Scan by scan, for a fixed field of view, each data point from interferometer tape 2 is assigned to a square on the U-V plane. The points in a single square are collected and a mean and variance calculated. This gives a value for phase and amplitude along

with an indication of the scattering within each square. (Bruce R. Hermann)

2394 Mathematics. Monotone Arrangements of Real Numbers. To try to determine whether given 16 arbitrary real numbers it is possible to arrange them in a 4x4 matrix such that every determinant of a 2x2 minor is non negative. (Appel)

2395 T Materials Research Laboratory. Mossbauer Analysis of Martensite. Analysis of Mossbauer data on the aging of iron carbon martensites. (C. R. Rarey)

2396 Electrical Engineering. Plot of Moon Data. This computer time will be used for the computing and plotting of curves of electron content obtained from measurements of Faraday Rotation performed jointly with the U.S. Army Electronics Command. An atlas of data for the year 1967 will be compiled and published from these plots. (H. D. Webb)

2397 T Education. Job Selection Factors as Related to Predominantly Black and Predominantly White Work Settings. Factor analysis---job selection factors. Correlation: anticipated racial work setting (B and W) and responses to job factors (+ and -). Correlation: Students at each college (B and W) and relationship between racial composition of college and anticipated racial work setting. (Jessica Daniel)

2398 Computer Science. Compressible Fluid Dynamics. New Eulerian Methods for the solution of miltidimensional, compressible, hydrodynamic flow problems will be investigated. In particular, algorithms having greater parallelism than those currently in use are desired. (Flowerdew)

2399 Electrical Engineering. C. P. Research. Problems pertaining to atmospheric charged particle behavior. (Hendricks)

2400 Clark, Dietz and Associates. Structural Analysis and Bookkeeping Structural analysis using ICES programs; bookkeeping. (M. F. Tigrak)

2401 Survey Research Laboratory. 040 - D. P. Runs. 040 - D. P. tabulation runs. (Ferber)

2402 Survey Research Laboratory. 040 - Faculty Center. 040 - Data Reduction Runs. (Ferber)

2403 Survey Research Laboratory. 033 - Data Processing Runs. 033 - Commuter Space Study Tabs. (Ferber)

2404 Survey Research Laboratory. 030 - Data Processing Runs. 030 - Data processing runs. (Ferber)

2405 Survey Research Laboratory. 030 - Data Reduction. 030 - Data Reduction Runs. (Ferber)

2406 Survey Research Laboratory. 015 - Data Processing Runs. Data preparation/tabs on study SRL#015 DEAF STUDY. (Ferber)

2407 Survey Research Laboratory. 015 - Data Reduction. 015 - Data Reduction runs: Deaf Study. (Ferber)

2409 Economics. Assets and Income Distribution. Particular types of income are, one might suppose, generated by particular types of assets. In the economic literature, however, some major categories of income, in contrast to others, are not typically associated with particular underlying assets. Income from work, which may reflect the worker's "assets" of education, geographic location, age etc., is an example. The project seeks to identify the main types of such assets and relate them to income flows. (Frankel)

2410 Geography. Numerical Texture Classification. Texture information for a large number of sediment samples will be analyzed by several numerical classification techniques in an attempt to establish meaningful texture categories for studying sediment patterns. (Nunnally)

2411 T Anthropology. Tichitt Tradition, Saharan Neolithic. Chi-Square and Standard deviation of sample of archaeological artifacts. (Munson)

2412 T Physical Education For Men. Caloric Cost of 28 Endurance Exercises. The problem deals with the calculation of RQ factors, net O_2, net CO_2, and the caloric costs of 28 endurance exercises.

The time will also be used to determine the intercorrelations of 20 variables (body measurements, heartograph measurements, all-out bicycle ride, and mile run time) on 120 subjects for a Special Project (PE 493) concerning the reliability of heartogram measures taken during exercise. (Le Foster)

2413 T Physical Education For Men. Analysis of a Communication Structure of a University Administrative Instructional Unit. The computer will be employed to run a clique analysis and sociomatrix on a sample of 205 persons in order to determine the communication patterns in the College of Physical Education. (Robert Case)

2414 Electrical Engineering. Analysis of Human Body Movements. Analysis of a certain class of human body rotational movements by computer simulation using Calcomp. Purpose: to devise a notation for defining body movements. (Jean Michl)

2416 Zoology. Studies in Vertebrate Social Behavior. Studies in vertebrate social behavior. (Edwin M. Banks)

2417 Electrical Engineering. Load Flow Problems. Load flow study of power system. (Egbert)

2418 T Zoology. Biomechanics of Heteromyid Leaping. Performing morphological integration on osteological characters in Heteromyids and analyzing forces in the jumping system. (Pinkham)

2420 Education. Factor Analytic Studies of State School Systems. This project is a factor analysis of a large number of variables on local school districts within five states: Utah, Idaho, Illinois, Florida, and

Kansas. The variables consist of measures on instructional programs, teaching and non-teaching staff, pupil characteristics, financial characteristics of the districts, structure of expenditures, and community characteristics. The problem involves obtaining least squares solution of these variables; and the application of factor analysis to identify a set of variables which best describe the characteristics of school systems within states. Also the problem involves using methods of discriminant analysis to identify variables which best describe common characteristics among states. The data were obtained from field surveys; state school reports; and U.S. Bureau of the Census. (W.P. McLure)

9.4 Class Problem Specifications

During the first quarter of 1969, 166 problem specifications were submitted to cover all assigned problems on the System/360 in the following courses.

2111	Civil Engineering 497.
2113	Psychology 216.
2114	Mathematics 388.
2115	Computer Science 101.
2116	Secondary Education 356.
2120	Architecture 347.
2124	Civil Engineering 322.
2125	Civil Engineering 202.
2131	Geology 336.
2133	Civil Engineering 497.
2137	Political Science 291.
2139	Psychology 494.
2142	Mechanical Engineering 293.
2143	Mechanical Engineering 323.

2144 Computer Science 397.

2145 Computer Science 397.

2147 Music 304.

2149 Aeronautical and Astronautical Engineering 429.

2151 Civil Engineering 262.

2152 Mechanical Engineering 423.

2154 Architecture 494.

2155 Electrical Engineering 497.

2156 Educational Psychology 496.

2157 Civil Engineering 405.

2158 Chemistry and Chemical Engineering 349.

2160 Mechanical Engineering 448.

2161 Mechanical Engineering 343.

2162 Mechanical Engineering 341.

2163 Mechanical Engineering 220.

2164 Mechanical Engineering 221.

2165 Mechanical Engineering 441.

2166 Mechanical Engineering 220.

2167 Theoretical and Applied Mechanics 412.

2170 Theoretical and Applied Mechanics 294.

2171 Theoretical and Applied Mechanics 493.

2172 General Engineering 103.

2174 Theoretical and Applied Mechanics 493.

2180 Aeronautical and Astronautical Engineering 241.

2185 Agricultural Engineering 299.

2186 Geology 321.

2187 Industrial Engineering 282.

2189 Economics 471.

2192 General Engineering 393.

2193 General Engineering 313.

2194 General Engineering 288.

2196 Mechanical Engineering 305.

2197 Agricultural Engineering 387.

2198 Agricultural Engineering 381.

2199 Mechanical Engineering 271.

2200 Agricultural Engineering 499.

2201 Business Administration 373.

2202 Business Administration 571.

2203 Accountancy 325.

2204 Civil Engineering 461.

2205 Chemistry and Chemical Engineering 261.

2206 Computer Science 101.

2207 Computer Science 101.

2208 Finance 450.

2209 Civil Engineering 220.

2210 Computer Science 413.

2211 Computer Science 103.

2212 Agricultural Economics 325.

2213 Physics 341.

2214 Political Science 484.

2215 Physics 303.

2216 Computer Science 387.

2217 Computer Science 201.

2219 Computer Science 306.

2220 Computer Science 290.

2221 Engineering Honors 297.

2224 Mechanical Engineering 263.

2225 Mechanical Engineering 264.

2226 Electrical Engineering 453.

2228 Electrical Engineering 323.

2229 Electrical Engineering 250.

2233 Nuclear Engineering 451.

2234 Civil Engineering 391.

2235 Civil Engineering 361.

2236 Civil Engineering 469.

2239 Electrical Engineering 322.

2240 Electrical Engineering 452.

2241 Chemistry 488.

2242 Mechanical Engineering 293.

2243 Mechanical Engineering 185 and 186.

2245 Mechanical Engineering 410.

2247 Agricultural Economics 220.

2250 Electrical Engineering 330.

2251 Theoretical and Applied Mechanics 426.

2252 Electrical Engineering 350.

2253 Electrical Engineering 342.

2254 Theoretical and Applied Mechanics 392.

2255 Electrical Engineering 498.

2256 Electrical Engineering 389.

2257 Electrical Engineering 324.

2258 Computer Science 101.

2259 Agricultural Economics 436.

2260 Agricultural Economics 236.

2261 Nuclear Engineering 495.

2265 General Engineering 232.

2266 General Engineering 231.

2267 General Engineering 242.

2268 Economics 295.

2269 Chemistry 381.

2270 Nuclear Engineering 458.

2276 Mechanical Engineering 224.

2277 Computer Science/Mathematics 458.

2278 Theoretical and Applied Mechanics 235.

2279 Theoretical and Applied Mechanics 334.

2281 Civil Engineering 261

2284 Aeronautical and Astronautical Engineering 233.

2286 Business Administration 533.

2288 Aeronautical and Astronautical Engineering 263.

2289 Civil Engineering 250.

2291 Electrical Engineering 382.

2294 Agricultural Engineering 336.

2297 Chemistry 385.

2298 Computer Science 290.

2299 Nuclear Engineering 455.

2301 Mechanical Engineering 207.

2302 Mechanical Engineering 448.

2303 Aeronautical and Astronautical Engineering 391.

2304 Aeronautical and Astronautical Engineering 334.

2305 Aeronautical and Astronautical Engineering 260.

2306 Mechanical Engineering 256.

2309 Economics 470.

2310 Civil Engineering 452.

2311 Educational Psychology 490.

2313 Economics 477.

2315 Mechanical Engineering 306.

2316 Electrical Engineering 251.

2317 Aeronautical and Astronautical Engineering 327.

2318 Music 320.

2319 Electrical Engineering 220.

2321 Electrical Engineering 373.

2324 Chemistry 379.

2326 Secondary Education 241.

2327 Electrical Engineering 297.

2328 Electrical Engineering 355.

2329 Computer Science 209.

2332 Electrical Engineering 386.

2333 Educational Psychology 495.

2334 Aeronautical and Astronautical Engineering 391.

2336 General Engineering 221.

2337 Computer Science 999.

2339 Civil Engineering 374.

2342 Mechanical Engineering 293.

2350 Civil Engineering 497.

2352 Finance 295.

2353 Mechanical Engineering 493.

2354 Zoology 303.

2368 Civil Engineering 315.

2369 Civil Engineering 417.

2371 Mechanical Engineering 260.

2375 Finance 450.

2376 Civil Engineering 458.

2377 Mechanical Engineering 314.

2378 Aeronautical and Astronautical Engineering 225.

2379 Mechanical Engineering 293.

2381 Psychology 493.

2383 Physics 490.

2389 Psychology 307.

2391 Theoretical and Applied Mechanics 224.

2393 Theoretical and Applied Mechanics 311.

2408 Electrical Engineering 420.

2415 Electrical Engineering 367.

2419 Civil Engineering 284.

10.1 Log Summaries

Table I - IBM 1401-II
Summary of Use
January, 1969

Scheduled Engineering	2:25
Unscheduled Engineering	55:58
Maintenance	4:15
7094 Preparation	494:14
List/Reproduce	16:35
Tape Dump	1:05
1604 Preparation	:07
Idle	22:26
Total	597:05

Table II - IBM 1401-II
Summary of Machine Errors
January, 1969

1401 Main Frame	1
1402 Card Reader Punch	8
1403 Printer	2
Total	11

Table I - IBM 7094

Summary of Use

January, 1969

Scheduled Engineering		23:32
Air Conditioning		1:50
Maintenance		2:58
Idle		44:20
Miscellaneous (Operator training, tape rewind, system tape mounting, rerun of failing problems)		71:44
Total Use		
Training and Education	22:10	
University Administrative Overhead Use	3:44	
System Improvement and Modifications	11:16	
System Accounting	8:16	
System Updating	:05	
Customer Use Total	237:59	
Total Use		283:30
Total Time		427:54

Table II - IBM 7094

Summary of Errors

January, 1969

There were no errors during January, 1969.

IBM 7094 TABLE III JANUARY, 1969

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 7094 USAGE IN HOURS-MINUTES-SECONDS			
	TANDE[2]	RES	TOTAL	TANDE[2]	RES	TOTAL	TANDE[2]	RESEARCH	REFUND	TOTAL
AAE	0	3	3	0	1	1		6 43		6 43
ACCY	0	2	2	0	2	2		54		54
ADV	0	13	13	0	3	3		59 16		59 16
AGE	0	1	1	0	1	1		1 33		1 33
AGEC	265	120	385	3	7	10	3 29 45	2 48 07		6 17 52
AGREXT	0	6	6	0	1	1		16 08		16 08
AGRON	0	10	10	0	3	3		29 56		29 56
ANS	0	57	57	0	4	4		1 37 35		1 37 35
ARCH	21	0	21	1	0	1	4 26			4 26
ASTR	0	66	66	0	4	4		1 16 28		1 16 28
ASTRMI	0	6	6	0	1	1		2 38 09		2 38 09
AVI	0	5	5	0	1	1		1 08		1 08
BINRES	0	57	57	0	1	1		49 51		49 51
CE	44	60	104	3	6	9	9 46	1 22 20		1 32 06
CHE	0	506	506	0	18	18		18 02 39		18 02 39
COMM	0	14	14	0	1	1		19 15		19 15
CRC	0	17	17	0	2	2		41 20		41 20
DCS	0	6	6	0	2	2		35 13		35 13
ECON	19	3	22	1	1	2	1 29 09	3 10		1 32 19
ED	0	102	102	0	7	7		1 59 14		1 59 14
EDPSY	196	11	207	3	1	4	4 45 31	44 38		5 30 09
EE	0	69	69	0	6	6		1 30 41		1 30 41
ENTOM	0	17	17	0	2	2		20 16		20 16
FIN	0	7	7	0	2	2		26 08		26 08
FOR	0	5	5	0	1	1		22 15		22 15
GENE	59	13	72	1	2	3	2 15 57	19 18		2 35 15
GEOG	0	5	5	0	1	1		2 27		2 27
GEOL	1	6	7	1	1	2	21	9 00		9 21
HEC	0	2	2	0	1	1		20 13		20 13
HED	0	54	54	0	1	1		1 00 18		1 00 18
HLTHSV	0	2	2	0	1	1		15 32		15 32
HONORS	0	4	4	0	1	1		3 43		3 43
ICR	0	199	199	0	3	3		5 32 44		5 32 44
IED	0	33	33	0	1	1		7 35 02		7 35 02
IGPA	0	16	16	0	1	1		5 02		5 02

ILR	0	25	25	0	3	3				1	09	41	1	09	41
INADM	0	23	23	0	1	1					23	16		23	16
IREC	0	12	12	0	1	1				1	11	52	1	11	52
LIBS	0	3	3	0	1	1					15	21		15	21
MATH	0	14	14	0	1	1				2	26	34	2	26	34
MATRL	0	258	258	0	13	13				8	49	51	8	49	51
MCBIO	0	7	7	0	1	1					3	54		3	54
ME	58	271	329	1	12	13		28	58	9	19	51	9	48	49
MMPE	0	49	49	0	2	2					25	08		25	08
NHS	0	36	36	0	2	2					27	18		27	18
NUCE	0	144	144	0	9	9				1	48	54	1	48	54
OIR	0	275	275	0	1	1				7	24	07	7	24	07
ORME	0	3	3	0	1	1					3	43		3	43
PEM	0	26	26	0	4	4					24	56		24	56
PHYB	0	44	44	0	3	3				1	19	51	1	19	51
PHYCS	0	163	163	0	6	6				5	18	23	5	18	23
PHYX	0	1047	1047	0	10	10				97	39	03	97	39	03
POLS	86	17	103	5	1	6	4	08	46		30	43	4	39	29
PROVST	0	17	17	0	2	2					28	50		28	50
PSYCH	166	818	984	4	21	25	4	29	37	20	37	12	25	06	49
REC	0	38	38	0	2	2				1	37	40	1	37	40
SCONS	0	15	15	0	1	1					3	50		3	50
SGS	0	28	28	0	2	2					44	34		44	34
SOC	134	76	210	2	7	9		25	19	3	24	22	3	49	41
SOCW	0	32	32	0	1	1				1	52	40	1	52	40
SPCH	0	2	2	0	1	1						14			14
SPED	0	10	10	0	1	1					6	46		6	46
SRL	0	55	55	0	3	3				3	39	46	3	39	46
SWS	0	433	433	0	14	14				12	59	48	12	59	48
VPP	0	21	21	0	1	1					21	43		21	43
ZOOL	0	2	2	0	1	1						32			32

SUBTOTAL	1079	5461	6540	26	220	246	22	09	25	237	56	39	260	06	04
DCSSYS[3]	0	301	301	0	7	7				19	32	20	19	32	20
SSUAD[4]	0	164	164	0	1	1				3	44	16	3	44	15
XDCS[5]	0	15	15	0	1	1					5	16		5	16
XSSS[6]	2	0	2	1	0	1									
SUBTOTAL	0	482	482	0	10	10				23	21	52	23	21	52
TOTALS	1079	5943	7022	26	230	256	22	09	25	261	18	31	283	27	56

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 University Administrative Overhead Use
5 System Updating
6 Special Short Shots

Table I - IBM 1401-II

Summary of Use

February, 1969

Scheduled Engineering		2:12
Unscheduled Engineering		11:45
Maintenance		3:27
7094 Preparation		464:49
List/Reproduce		8:50
Tape Dump		3:31
Idle		55:59
	Total	550:33

Table II - IBM 1401-II

Summary of Machine Errors

February, 1969

1402 Card Reader Punch		4
1403 Printer		1
	Total	5

Table I - IBM 7094

Summary of Use

February, 1969

Scheduled Engineering		22:33
Air Conditioning		3:20
Maintenance		5:17
Idle		41:01
Miscellaneous (Operator training, tape rewind, rerun of failing problems)		66:18
Total Use		
Training and Education	6:05	
University Administrative Overhead Use	7:06	
System Improvement and Modifications	16:13	
System Accounting	6:43	
System Updating	:03	
Customer Use Total	211:52	
Total Use		248:02
Total Time		386:31

Table II - IBM 7094

Summary of Errors

February, 1969

There were no errors during February, 1969.

IBM 7094 TABLE III FEBRUARY, 1969

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	IBM 7094 USAGE IN HOURS-MINUTES-SECONDS TANDE[2]	RESEARCH	REFUND	TOTAL
AAE	0	5	5	0	1	1		12 36		12 36
ACCY	0	15	15	0	1	1		42 28		42 28
ADV	0	8	8	0	2	2		26 34		26 34
AGE	0	9	9	0	2	2		9 03		9 03
AGEC	0	117	117	0	8	8		6 16 45		6 16 45
AGRON	0	10	10	0	2	2		42 17		42 17
ANS	8	25	33	1	3	4	5 42	23 59		29 41
ANTH	35	0	35	1	0	1	13 51			13 51
ASTR	0	95	95	0	4	4		1 26 23		1 26 23
ASTRMI	0	2	2	0	1	1		15 18		15 18
BIVRES	0	133	133	0	2	2		2 56 59		2 56 59
CCSCS	0	9	9	0	1	1		19 15		19 15
CE	0	65	65	0	7	7		1 36 47		1 36 47
CHE	0	548	548	0	22	22		21 59 33		21 59 33
COMM	0	5	5	0	1	1		6 00		6 00
CRC	0	36	36	0	3	3		53 23		53 23
DS	0	4	4	0	1	1		1 22		1 22
ECON	6	32	38	1	2	3	26 09	11 30		37 39
ED	0	79	79	0	9	9		2 05 10		2 05 10
EDPSY	56	0	56	2	0	2	15 06			15 06
EE	6	62	68	1	5	6	24 57	43 54		1 08 51
ENGCST	0	1	1	0	1	1		14		14
ENTOM	0	20	20	0	2	2		29 05		29 05
FIN	0	1	1	0	1	1		10		10
GENE	0	26	26	0	1	1		56 45		56 45
GEOG	0	10	10	0	1	1		4 12		4 12
GEOL	0	3	3	0	1	1		5 09		5 09
HED	0	60	60	0	1	1		1 14 20		1 14 20
HLTHSV	0	1	1	0	1	1		5 42		5 42
HONORS	0	10	10	0	1	1		20 56		20 56
ICR	0	264	264	0	3	3		10 43 21		10 43 21
IED	0	38	38	0	1	1		4 16 08		4 16 08
ILR	0	11	11	0	2	2		51 57		51 57
INADM	0	18	18	0	1	1		21 46		21 46
LIBS	0	20	20	0	2	2		32 09		32 09

MATH	0	4	4	0	1	1		8 00 28		8 00 28
MATRL	0	249	249	0	14	14		5 42 26		5 42 26
MCBIO	0	8	8	0	1	1		4 58		4 58
ME	39	350	389	1	11	12	19 55	9 32 37		9 52 32
MMPE	0	15	15	0	2	2		4 00		4 00
MUSIC	2	3	5	1	1	2	21	5 52		6 13
NHS	0	8	8	0	1	1		46 06		46 06
NUCE	0	63	63	0	8	8		1 24 23		1 24 23
OIR	0	124	124	0	1	1		3 56 56		3 56 56
ORME	0	1	1	0	1	1		1 01		1 01
PEM	0	46	46	0	3	3		15 56		15 56
PHYB	0	45	45	0	4	4		1 45 53		1 45 53
PHYCS	0	153	153	0	7	7		7 35 32		7 35 32
PHYX	0	727	727	0	10	10		69 02 48		69 02 48
POLS	46	0	46	3	0	3	3 29 23			3 29 23
PRGVST	0	11	11	0	1	1		11 16		11 16
PSYCH	17	757	774	3	21	24	5 27	16 31 45		16 37 12
REC	0	23	23	0	2	2		1 26 20		1 26 20
SCONS	0	8	8	0	1	1		4 22		4 22
SGS	0	54	54	0	3	3		23 09		23 09
SOC	11	101	112	2	4	6	40 47	5 36 56		6 17 43
SOCW	0	19	19	0	1	1		27 54		27 54
SPED	1	0	1	1	0	1	3 25			3 25
SRL	0	81	81	0	2	2		11 00 31		11 00 31
SWS	0	361	361	0	12	12		5 49 10		5 49 10
TAM	0	1	1	0	1	1		14		14
VPF	0	4	4	0	1	1		13 08		13 08
VPP	0	32	32	0	1	1		9 00		9 00
WIVLAB	0	4	4	0	1	1		1 51		1 51
ZOOL	0	16	16	0	3	3		4 39		4 39
SUBTOTAL	227	5010	5237	17	215	232	6 05 03	211 50 23		217 55 26
DCSSYS[3]	0	383	383	0	5	5		22 56 20		22 56 20
SSUAD[4]	0	114	114	0	1	1		7 06 03		7 06 03
XDCS[5]	0	9	9	0	1	1		2 56		2 56
XSSS[6]	0	3	3	0	1	1				
SUBTOTAL	0	509	509	0	8	8		30 05 19		30 05 19
TOTALS	227	5519	5746	17	223	240	6 05 03	241 55 42		248 00 45

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 University Administrative Overhead Use
5 System Updating
6 Special Short Shots

Table I - IBM 1401-II

Summary of Use

March, 1969

Scheduled Engineering		5:20
Unscheduled Engineering		5:50
Maintenance		3:28
7094 Preparation		455:04
List/Reproduce		8:32
Tape Dump		:05
1604 Preparation		:20
Idle		117:31
	Total	596:10

Table II - IBM 1401-II

Summary of Machine Errors

March, 1969

1402 Card Reader Punch		2
	Total	2

Table I - IBM 7094

Summary of Use

March, 1969

Scheduled Engineering		13:28
Unscheduled Engineering		1:36
Air Conditioning		39:43
Maintenance		3:01
Idle		46:17
Miscellaneous (Operator training, tape rewind, rerun of failing problems)		56:49
Total Use		
Training and Education	12:42	
University Administrative Overhead Use	5:32	
System Improvement and Modifications	18:48	
System Accounting	6:04	
System Updating	:05	
Customer Use Total	218:34	
Total Use		261:45
Total Time		422:39

Table II - IBM 7094

Summary of Errors

March, 1969

Punch	1
Total	1

IBM 7C94 TABLE III MARCH, 1969

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	IBM 7094 USAGE IN HOURS-MINUTES-SECONDS TANDE[2]	RESEARCH	REFUND	TOTAL
AAE	0	2	2	0	2	2		32		32
ACCY	0	21	21	0	1	1		10 55		10 55
ADV	0	5	5	0	2	2		5 06		5 06
AGEC	8	192	200	1	9	10	57	7 21 39		7 22 36
AGRON	0	5	5	0	2	2		9 49		9 49
ANS	2	46	48	1	3	4	2 56	1 03 23		1 06 19
ANTH	9	0	9	1	0	1	6 57			6 57
ASTR	0	85	85	0	3	3		52 14		52 14
ASTRMI	0	2	2	0	1	1		1 06 18		1 06 18
BINRES	0	154	154	0	2	2		2 40 47		2 40 47
CCSCS	0	6	6	0	1	1		6 57		6 57
CE	0	20	20	0	4	4		16 29		16 29
CHE	0	524	524	0	21	21		21 03 19		21 03 19
CRC	0	94	94	0	3	3		2 13 32		2 13 32
DGS	0	1	1	0	1	1		1 04		1 04
ECCN	0	2	2	0	1	1		2 02		2 02
ED	90	70	160	2	12	14	2 45 50	1 09 53		3 55 43
EDADM	0	5	5	0	1	1		16 48		16 48
EDPSY	27	0	27	2	0	2	7 47			7 47
EE	4	53	57	1	5	6	2 24	58 47		1 01 11
ENGCST	0	2	2	0	1	1		9 18		9 18
ENTOM	0	9	9	0	2	2		5 34		5 34
FIN	0	2	2	0	1	1		1 01		1 01
FOR	0	4	4	0	2	2		6 06		6 06
FT	0	6	6	0	2	2		1 33		1 33
GENE	0	9	9	0	2	2		8 34		8 34
GSA	0	2	2	0	1	1		03		03
HED	0	25	25	0	1	1		1 16 30		1 16 30
HONORS	0	14	14	0	1	1		1 07 37		1 07 37
HORT	0	2	2	0	1	1		1 08		1 08
ICR	0	362	362	0	4	4		16 57 31		16 57 31
IEC	0	46	46	0	1	1		6 13 30		6 13 30
ILR	0	13	13	0	2	2		1 12 25		1 12 25
INADM	0	2	2	0	1	1		54		54
LIBS	0	2	2	0	1	1		5 09		5 09

IBM 7094 TABLE III MARCH, 1969 -CONT

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	IBM 7094 USAGE IN HOURS-MINUTES-SECONDS TANDE[2]	RESEARCH	REFUND	TOTAL
MATRL	0	245	245	0	11	11		6 25 15		6 25 15
MCBIO	0	3	3	0	1	1		1 37		1 37
ME	70	420	490	1	11	12	27 25	18 50 30		19 17 55
MMPE	0	53	53	0	2	2		19 37		19 37
MUSIC	4	6	10	1	1	2	50	10 04		10 54
NHS	0	15	15	0	3	3		1 01 36		1 01 36
NUCE	0	53	53	0	5	5		1 16 27		1 16 27
OIR	0	147	147	0	1	1		3 55 40		3 55 40
ORME	0	1	1	0	1	1		28		28
PEM	0	117	117	0	7	7		46 16		46 16
PHYB	0	27	27	0	3	3		1 49 04		1 49 04
PHYCS	0	153	153	0	7	7		8 18 51		8 18 51
PHYX	0	949	949	0	10	10		83 09 11		83 09 11
POLS	82	1	83	2	1	3	6 09 39	07		6 09 46
PRCVST	0	8	8	0	1	1		10 51		10 51
PSYCH	61	705	766	1	27	28	1 04 04	11 23 40		12 27 44
REC	0	40	40	0	4	4		1 24 41		1 24 41
SCCNS	0	6	6	0	1	1		2 45		2 45
SGS	0	57	57	0	2	2		47 45		47 45
SOC	174	93	267	2	6	8	1 40 11	3 46 24		5 26 35
SOCW	0	3	3	0	1	1		19 48		19 48
SPED	3	2	5	1	1	2	12 43	2 38		15 21
SRL	0	83	83	0	3	3		5 20 59		5 20 59
SWS	0	113	113	0	11	11		1 47 09		1 47 09
VPH	0	1	1	0	1	1		25		25
VPP	0	17	17	0	1	1		5 09		5 09
VTED	0	20	20	0	2	2		7 07		7 07
ZOOL	0	7	7	0	2	2		2 02		2 02
SUBTOTAL	534	5132	5666	16	224	240	12 41 43	218 32 33		231 14 16
CCSSYS[3]	0	359	359	0	6	6		24 51 54		24 51 54
UADP[4]	0	79	79	0	1	1		5 31 40		5 31 40
XDCS[5]	0	12	12	0	1	1		5 24		5 24
XSSS[6]	0	9	9	0	1	1				
TOTALS	534	5591	6125	16	233	249	12 41 43	249 01 31		261 43 14

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 University Administrative Overhead Use
5 System Updating
6 Special Short Shots

7094 TABLE III 1ST QT. 1969

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			7094 USAGE IN HOURS-MINUTES		
	TANDE[2]	RES	TOTAL	TANDE[2]	RES	TOTAL	TANDE[2]	RES	TOTAL
AAE	C	10	10	0	4	4	0.0	19.8	19.8
ACCY	C	38	38	0	4	4	0.0	54.2	54.2
ADV	C	26	26	0	7	7	0.0	1 30.9	1 30.9
AGE	C	10	10	0	3	3	0.0	10.6	10.6
AGEC	273	429	702	4	24	28	3 30.7	16 26.6	19 57.4
AGREX	C	6	6	0	1	1	0.0	16.1	16.1
AGRCN	C	25	25	0	7	7	0.0	1 22.0	1 22.0
ANS	10	128	138	2	10	12	8.6	3 5.0	3 13.6
ANTH	44	0	44	2	0	2	20.8	0.0	20.8
ARCH	21	0	21	1	0	1	4.4	0.0	4.4
ASTR	C	246	246	0	11	11	0.0	3 35.1	3 35.1
ASTRM	C	10	10	0	3	3	0.0	3 59.7	3 59.7
AVI	C	5	5	0	1	1	0.0	1.1	1.1
BINRE	C	344	344	0	5	5	0.0	6 27.6	6 27.6
CCSCS	C	15	15	0	2	2	0.0	26.2	26.2
CE	44	145	189	3	17	20	9.7	3 15.7	3 25.4
CHE	C	1578	1578	0	61	61	0.0	61 5.9	61 5.9
COMM	C	19	19	0	2	2	0.0	25.2	25.2
CRC	C	147	147	0	8	8	0.0	3 48.2	3 48.2
DCS	C	6	6	0	2	2	0.0	35.2	35.2
DGS	C	1	1	0	1	1	0.0	1.0	1.0
DS	C	4	4	0	1	1	0.0	1.3	1.3
ECON	25	37	62	2	4	6	1 55.3	16.7	2 12.0
ED	90	251	341	2	28	30	2 45.8	5 14.4	8 0.2
EDADM	C	5	5	0	1	1	0.0	16.7	16.7
EDPSY	279	11	290	7	1	8	5 8.4	44.6	5 53.0
EE	10	184	194	2	16	18	27.3	3 13.4	3 40.7
ENGCS	C	3	3	0	2	2	0.0	9.5	9.5
ENTOM	C	46	46	0	6	6	0.0	54.9	54.9
FIN	C	10	10	0	4	4	0.0	27.3	27.3
FOR	C	9	9	0	3	3	0.0	28.3	28.3
FT	C	6	6	0	2	2	0.0	1.5	1.5
GENE	59	48	107	1	5	6	2 15.9	1 24.6	3 40.6
GEOG	C	15	15	0	2	2	0.0	6.6	6.6

7094 TABLE III 1ST QT. 1969- CONT

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			7094 USAGE IN HOURS-MINUTES		
	TANDE[2]	RES	TOTAL	TANDE[2]	RES	TOTAL	TANDE[2]	RES	TOTAL
GEOL	1	9	10	1	2	3	0.3	14.1	14.5
GSA	0	2	2	0	1	1	0.0	0.0	0.0
HEC	0	2	2	0	1	1	0.0	20.2	20.2
HED	0	139	139	0	3	3	0.0	3 31.1	3 31.1
HLTHS	0	3	3	0	2	2	0.0	21.2	21.2
HONOR	0	28	28	0	3	3	0.0	1 32.2	1 32.2
HORT	0	2	2	0	1	1	0.0	1.1	1.1
ICR	0	825	825	0	10	10	0.0	33 13.6	33 13.6
IED	0	117	117	0	3	3	0.0	18 4.6	18 4.6
IGPA	0	16	16	0	1	1	0.0	5.0	5.0
ILR	0	49	49	0	7	7	0.0	3 14.0	3 14.0
INADM	0	43	43	0	3	3	0.0	45.9	45.9
IREC	0	12	12	0	1	1	0.0	1 11.8	1 11.8
LIBS	0	25	25	0	4	4	0.0	52.6	52.6
MATH	0	18	18	0	2	2	0.0	10 27.0	10 27.0
MATRL	0	752	752	0	38	38	0.0	20 57.7	20 57.7
MCBIO	0	18	18	0	3	3	0.0	10.4	10.4
ME	167	1041	1208	3	34	37	1 16.3	37 43.1	38 59.5
MMPE	0	117	117	0	6	6	0.0	48.7	48.7
MUSIC	36	9	45	3	2	5	23.0	15.9	39.0
NHS	0	59	59	0	6	6	0.0	2 15.0	2 15.0
NUCE	0	260	260	0	22	22	0.0	4 29.8	4 29.8
OIR	0	546	546	0	3	3	0.0	15 16.7	15 16.7
ORME	0	5	5	0	3	3	0.0	5.2	5.2
PEM	0	189	189	0	14	14	0.0	1 27.2	1 27.2
PHYB	0	116	116	0	10	10	0.0	4 54.8	4 54.8
PHYCS	0	469	469	0	20	20	0.0	21 12.8	21 12.8
PHYX	0	2723	2723	0	30	30	0.0	249 51.2	249 51.2
POLS	214	18	232	10	2	12	13 47.8	30.8	14 18.7
PROVS	0	36	36	0	4	4	0.0	50.9	50.9
PSYCH	244	2280	2524	8	69	77	5 39.1	48 33.0	54 12.2
REC	0	101	101	0	8	8	0.0	4 28.7	4 28.7
SCONS	0	29	29	0	3	3	0.0	10.9	10.9
SGS	0	139	139	0	7	7	0.0	1 55.4	1 55.4
SOC	319	270	589	6	17	23	2 46.3	12 47.8	15 34.1
SOCW	0	54	54	0	3	3	0.0	2 40.3	2 40.3

7094 TABLE III 1ST QT. 1969- CONT

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			7094 USAGE IN HOURS-MINUTES		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
SPCH	0	2	2	0	1	1	0.0	0.2	0.2
SPED	4	12	16	2	2	4	16.1	9.4	25.5
SRL	0	219	219	0	8	8	0.0	20 1.3	20 1.3
SWS	0	907	907	0	37	37	0.0	20 36.3	20 36.3
TAM	0	1	1	0	1	1	0.0	0.2	0.2
VPH	0	5	5	0	2	2	0.0	13.5	13.5
VPP	0	70	70	0	3	3	0.0	35.8	35.8
VTED	0	20	20	0	2	2	0.0	7.1	7.1
WIVLA	0	4	4	0	1	1	0.0	1.8	1.8
ZOOL	0	25	25	0	6	6	0.0	7.2	7.2
SUBTOTAL	1840	15603	17443	59	659	718	40 56.6	668 24.1	709 20.7
DCSSYS[3]	0	1043	1043	0	18	18	0.0	67 20.6	67 20.6
UADP[4]	0	357	357	0	3	3	0.0	16 22.0	16 22.0
XDCS[5]	0	36	36	0	3	3	0.0	13.6	13.6
XSSS[6]	0	14	14	0	3	3	0.0	0.0	0.0
TOTAL	1840	17053	18893	59	686	745	40 56.6	752 20.3	793 16.9

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 University Administrative Overhead Use
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10.2 Research Problem Specifications

During the first quarter of 1969, 48 problem specifications were submitted to the Department for computation on the 7094. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

3339-91001 Bureau of Institutional Research. Staff Analysis. Analysis of University staff and students with respect to staff appointments, length of service, etc. (John Terwilliger)

3340-91005 Institute of Communications Research. The present studies investigate the parameters of human judgment across a variety of situations. In particular, the variables of interest are: (a) the trans-situational generality of preference and similarity judgments; (b) the outside correlates of such judgments; and (c) the isolation and prediction of individual differences in judgment types. Multivariate methods of analysis will be used including factor analysis, multidimensional scaling, canonical correlation, discriminant function analysis and multivariate analysis of variance. (Wiggins)

3341-91007 T Accountancy. Simultaneous Equation Estimations. Sampling Theory, Theil-Goldberger, and Bayesian Treatment of prior information. Comparative study of simultaneous equation estimation techniques using Monte-Carlo experiments. (Saadia Montasser)

3342-91009 Survey Research Laboratory. Analysis Runs. SSUPAC analysis runs on survey data. (M. F. Uchida)

3343-91012 T Psychology. Analyses of SBSGI and NOSIE-30, and Use of Tarse Instruments with Hospitalized Patients. Multiple analysis by SSUPAC. (Robert Lentz)

3344-91013 T Advertising. Japanese American Acculturation Research. The thesis is an empirical study of the influences of mass and interpersonal communications upon the acculturation of an ethnic group in U.S. society. (Kiyoshi Nagata)

3345-91016 T Western Illinois University Laboratory School. Rhythm and Relaxation Training. Analysis of covariance to determine factors existent in a training program of rhythm and relaxation. (Carolyn Colvin)

3346-91019 Psychology. New Forms Analysis. A number of experiments have been conducted on pattern-component learning. The present analysis is a standard analysis of variance to determine the effects of variables such as list structure, component type, etc. (Steiner)

3347-92006 T Education. A Prediction of Superior Artistic Performance from Cognitive and Non-Cognitive Measures. The purpose of this study is to develop a multiple prediction equation which could provide a more adequate method of selecting college art students; students who would still perform successfully in academic courses, but who would perform more successfully in art courses. The problem will be to determine if there is a difference in the personality, motivation, and intelligence patterns of students who have produced an identified superior art object from those students who have produced an identified inferior art object. The prediction equation gives psychological insight into what produces an artistic product, thus gaining practical prediction and psychological understanding. (Nancy Goodwin)

3348-92007 T Educational Administration. Efficiency of Structures. The problem is to identify factors that affect the efficiency of structures for higher education and, if possible, to ascertain the nature of the relationship which exists between these factors and certain types of nonassignable space. The nature of the data processing involved is such that SSUPAC MUST BE USED FOR THIS PROJECT. (Thomas Goins)

3349-92008 Library Science. Public Library Government Organization and Support. The objectives of this study are to study the various aspects of the operation and control of public libraries in the United States. (Carol Kronus)

3350-92009 T Agricultural Economics. Effect of Wage Rate on Job Mobility and Part-Time Work. Regression Analysis is to be used to determine effect of current job, location of residence, job training, age, and education on wage rate received. Several data transformations are necessary. (P.L. Wahi)

3351-92010 T Psychology. Some Factors of the Attribution Process Mediating Reciprocity. An investigation of Gouldner's Theory of Reciprocity with particular emphasis on the trait attribution by the receiver towards the donor as well as amount of reciprocity and other behavioral intentions of the receiver towards the donor. (Thomanek)

3352-92013 Psychology. Antecedents of Child Personality. A specification of the structure of child rearing patterns (assessed by parent interviews and social workers' ratings) and child personality (assessed by teachers' ratings and performance in various experimental situations) by factor analytic techniques. Following structure specification factors in the personality realm are to be predicted from child rearing pattern factors, singly and in combination, through multiple regression techniques. (Dielman)

3353-92014 Psychology. Vigilance. Research to investigate the effect of decision processes on simple monitoring performance. (Williges)

3354-92016 Education. Class Preference as a Function of Conceptual Level and Instructional Style. Research involves determining patterns of student class preference and performance as a function of student personality matched with style and content of class instruction. (Martin L. Maehr)

3355-92017 T Recreation. Effects of a Creative Problem Solving Workshop on Selected Municipal Recreation Personnel. The problem of this study is to analyze the effectiveness of a creative problem solving technique as presented in workshops conducted in the Chicago Park District and the Detroit Department of Parks and Recreation. Two parallel studies are being conducted, with experimental and control groups in each city, the experimental groups being those having the workshop. The investigator is attempting to ascertain whether or not the above mentioned workshop increases an individual's problem solving ability, develops a systematic multi-idea approach to problem solving, and improves an individual's job performance. Correlations, difference scores and ANOVA will be used in statistical analysis. (Jeanne E. Sherrow)

3356-92020 Office of the Dean of Women. Transfer Student Research Project. Questionaire information related to the transfer student study conducted by the office of the Dean of Student Personnel. (Marigrace Welsh)

3357-92021 T Institute of Communications Research. Japanese American Acculturation Research. The thesis is an empirical investigation of the influences of mass and interpersonal communications upon acculturation of an ethnic group in U.S. society. (Kiyoshi Nagata)

3358-92025 T Psychology. Cognitive Dissonance and Recall of Interrupted and Completed Tasks. The purpose of the present study is to explore the possibility of explaining differential recall of completed and interrupted tasks in terms of the theory of cognitive dissonance. Specifically, the experiment is designed to ascertain the effects of the following dissonance-arousal and -reduction variables on recall of completed and interrupted tasks: (1) the subject's degree of volition in commitment to the task, (2) the subject's level of expectation of task completion, and (3) the subject's tendency to utilize selective forgetting as a means of reducing dissonance. (Kuo-shu Yang)

3359-92026 T Education. Junior College Attitude Survey. Analysis of attitudinal scale utilizing factorial analysis and item discrimination analysis. "t" tests and analysis of variance will be used to determine the ability of the scale to discriminate among known populations. (Gary James)

3360-93002 Physical Education for Men. Evaluation of Certain Aspects of Physical Education Doctorates. This is a descriptive survey which compares the experiences and attitudes of certain groups of recent doctoral recipients in physical education and also compares the attitudes of these recent recipients with the attitudes of graduate advisers in physical education. (Dennis Fallon)

3361-93003 T Sociology. The Police Sergeant, an Analysis of his Career and Attitudes. The social characteristics and attitude responses of police sergeants will be analyzed as a function of the police sergeant's position in the organizational milieu. Organizational flow charts will be employed with special attention paid to the sergeant's career progression through time and position. SSUPAC will be employed as the programming language. (Robert E. Ford)

3362-93004 Political Science. Guatemala Study. Statistical analysis of survey data collected in Guatemala. (Meehan)

3363-93005 T Political Science. Cohort Analysis of Political Opinions. A 20-year time series analysis of age cohorts with respect to selected political opinions using survey data. (Klecka)

3364-93007 T Physical Education for Men. Leadership Behavior of Junior College and University Physical Education Administrators. Leadership behavior of junior college and university physical education administrators. (Zeigler)

3365-93008 T Psychology. Dimensional Preference and Oddity Learning. Study ascertains to see whether dimensional dominance in young children can be altered by oddity training. Training was given on the preferred and non-preferred dimension and dominance was measured shortly thereafter and one week thereafter. (Albert)

3366-93009 T Physical Education for Men. Analysis of Communication Structure of Univ. Admin. and Instruc. Unit. SSUPAC will be employed to run a clique analysis and sociomatrix on a sample of 205 persons in order to determine the communication patterns in the College of Physical Education. (Robert Case)

3367-93010 T Physical Education for Men. Resting Electrocardiographic Measurements. The long-term effects of exercise in middle-aged men by the measurements of their resting electrocardiographic characteristics. The t test was used to determine any significant differences between the two groups on $test_1$. Same test was used to determine any significant differences between the two groups on $test_2$ for those measurements on which the two groups did not differ on $test_1$. For the measurements on which the two groups differed on $test_1$ the analysis of covariance was employed. (Marcil)

3368-93011 Vocational and Technical Education. Comparison of the Effectiveness of Microfilm vs. Hard Copy. Student performance will be compared in relation to achievement on reading tasks presented by three different methods: 1. positive image microfiche, 2. negative image microfiche, and 3. hard copy. SSUPAC programs will be used exclusively. (Bailey)

3369-93012 Finance. Growth Rates of Nonlife Insurance Companies. Calculation of average rates of asset growth for a 180 firm sample of nonlife insurers removing the effects of external financing via a mathematical model. Calculation of average rates of growth adding a full dividend retention assumption via a mathematical model. Analysis of variance of resulting rates by stock and mutual insurers and four size categories of insurers (based upon admitted assets at the end of 1954). Tabulations of external financing totals by size and organizational categories. (Stephen Forbes)

3370-93013 T Recreation. Comparison of Music Sensitivity of Mongoloid and Normal Children. The problem is to accept or reject the null hypothesis that there is no significant difference in innate musical sensitivity between groups of Mongoloid and normal children at two levels of chronological age and mental age. Music sensitivity test scores secured from the four groups are to be subjected to statistical analysis, including analysis of variance. (Martha Peters)

3371-93014 T Psychology. Transfer of Stimulus Control. Transfer of stimulus control. ANOVA and correlation matrices. (Silikovitz)

3372-93015 T Psychology. AB Theory: A New Approach to Evaluative Information Integration. Prediction of evaluations of complex stimuli based upon evaluations of the components of the stimuli. (Howard Marcum)

3373-93016 T Physical Education for Men. Attitude Change Through Cognitive Dissonance. The purpose of the study is to determine the effects of role playing under high and low justification upon students' attitudes toward required college courses. Statistical analysis employed will be analysis of variance, analysis of covariance, and correlations. (Altalib)

3374-93017 T Physical Education for Men. The Relationship Between Maximal Oxygen Consumption and the Time Components of the Left Ventricle During Work. The purpose of this investigation is to determine the relationship between maximal oxygen consumption and the time components of the left ventricle at rest, during a moderate, and during a hard ride on the bicycle ergometer. Statistical Procedure: correlational procedures. (S. Molnar)

3375-93018 T Physical Education for Men. Fluid IQ and Physiological Variables. Correlation Matrix. Running means, 2 scores, 4 standard deviations of various groups of data. Partial correlation coefficient and multiple "R" T test. (Powell)

3376-93019 Survey Research Lab. 015 - Data Processing SSUPAC Runs. SSUPAC Runs for Deaf Study, SRL #015. (Ferber)

3377-93020 Survey Research Lab. 015 - Data Reduction Runs. 015 - data reduction cleaning runs; SSUPAC runs; for Deaf Study. (Ferber)

3378-93021 Survey Research Lab. Administrative Cost Control. Cost control program runs. (Ferber)

3379-93022 Survey Research Lab. 030 - Cleaning Runs. 030 - data reduction cleaning and SSUPAC runs. (Ferber)

3380-93023 Survey Research Lab. 030 - Data Processing SSUPAC Runs. 030 SSUPAC runs; data processing. (Ferber)

3381-93024 Survey Research Lab. 033 - D.P. SSUPAC Runs. 033 - Chicago campus commuter space survey SSUPAC tabs. (Ferber)

3382-93025 Survey Research Lab. 040 - Data Cleaning. 040 - faculty center data cleaning, SSUPAC runs. (Ferber)

3383-93026 Survey Research Lab. 040 Tabs. 040 SSUPAC tabs. (Ferber)

3384-93027 T Physical Education for Men. Effects Basic Movement and Swimming Have on Physical Fitness of Women. The purpose of this study is to determine the effects of a swimming class, a basic movement class and a control group on selected physical fitness variables. The physical fitness variables are power, strength, endurance, flexibility, agility, balance, cardiovascular endurance, and percent body fat. The analysis of variance will be used for the initial testing period to determine the significant differences among the groups (.10 level). The analysis of covariance will be used on the final testing period. (Jane E. Babka)

3385-93028 T Psychology. The relationship of Expectancy and Environmental Return to Satisfaction with Performance. The study is designed to investigate the effects of expectancy and performance level on satisfaction with performance. The computer facilities will be used for statistical procedures such as multiple regression, correlation, analysis of variance, and multiple analysis of variance. (Daniel R. Ilgen)

3386-93029 Home Economics. Support of Aged Parents. The effects of such variables as sex, generation, education, religion, birth order, place of residence, socio-economic status, and race on the willingness to support aged parents will be investigated. (Sandra Wake)

10.3 Class Problem Specification

During the first quarter of 1969, 24 problem specifications were submitted to cover all assigned problems on the 7094 in the following courses.

J974-91004 Anthropology 351.

J975-91008 Political Science 305.

J976-91010 Political Science 291.

J977-91011 Music 304.

J978-91015 Special Education 449.

J979-91017 Animal Science 103.

J980-91018 Sociology 185.

J981-91020 Political Science 484.

J982-91021 Mechanical Engineering 293.

J983-92001 Political Science 199.

J984-92002 Political Science 453.

J985-92003 Educational Psychology 390.

J986-92004 Agricultural Economics 220.

J987-92005 Electrical Engineering 497.

J988-92011 Sociology 387.

J989-92012 Mechanical Engineering 293.

J990-92015	Secondary Education 449.
J991-92018	Music 244.
J992-92019	Psychology 390.
J993-92022	Educational Psychology 495.
J994-92023	Educational Psychology 490.
J995-92024	Educational Psychology 449.
J996-93001	Educational Psychology 492.
J997-93006	Political Science 306.

11. GENERAL DEPARTMENT INFORMATION

11.1 Personnel

The number of people associated with the Department in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	24.0	2.0	25.30
Visiting Faculty	2.0	0	2.00
Research Associates	4.0	0	4.00
Graduate Research Assistants	12.0	104.0	65.65
Graduate Teaching Assistants	0	11.0	4.84
Professional Personnel	31.0	3.0	33.17
Administrative and Clerical	29.0	0	29.0
Nonacademic Personnel (Monthly)	66.0	1.0	66.50
Nonacademic Personnel (Hourly)	0	133.0	42.40
TOTAL	165.0	254.0	272.86

The Department Advisory Committee consists of Professor J. R. Pasta, Head of the Department; Professor J. N. Snyder, Associate Head of the Department; Professors K. W. Dickman, M. Faiman, L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J. Nievergelt, R. S. Northcote, J. R. Phillips, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, P. E. Saylor, and D. L. Slotnick.

11.2 Bibliography

During the first quarter, the following publications were issued by the Laboratory:

File Numbers

(1) Borovec, R. T., "Specifications for Wire-Wrap Wiring of Integrated Circuit Board 1018-299-00," File No. 550-126, March 13, 1969.

(2) Dunn, L.A., Lakshmi, N. G., and Tareski, V. G., "Programmed Aids for the Scan-Display System of Illiac III," File No. 794, March 14, 1969.

(3) Engineering Open House - 1969 (Department of Computer Science)," File No. 795, March 8, 1969.

(4) Gear, C., Whaley, A. and Weidenhofer, N., "The University of Illinois Plorts System--Phase 0* Provisional User's Manual," File No. 793, March, 1969.

(5) Katz, M. L., "New and Revised Mathematical Subroutines for Illiac IV," File No. 787, January 27, 1969.

(6) Krabbe, S. P., "Specifications for the Mechanical Termination of Twisted Pair Transmission Line Z_0 = 95 ohms ± 5 ohms with Burndy Contracts in the Illiac III Exchange Net," File No. 550-123, January 28, 1969.

(7) Krabbe, S. P., "Specifications for the Power Wiring of Section 7 (Arithmetic Unit) of the Illiac III Computer System," File No. 550-124, February 5, 1969.

(8) Krabbe, S. P., "Specifications for Termi-Point Wiring of Section 7 (Arithmetic Unit) of the Illiac III Computer System," File No. 550-125, February 18, 1969.

(9) Krabbe, S. P., "A Discussion of Illiac III Processor-Unit Communication Via the Exchange Net," File No. 790, March 4, 1969.

(10) Krabbe, S. P., "Specifications for the Mechanical Termination of Coaxial Cables (RG-195/U) Used in the Illiac III System," File No. 550-127, March 11, 1969.

(11) Lawrie, D. W., "Glypnir Operation Manual," File No. 792, March 10, 1969.

(12) McCarthy, T., "Solving a Set of Ordinary Differential Equations Involving a Large Matrix," File No. 786, January 27, 1969.

(13) Schwebel, J. C., "Toward the Specification of a New Image Processing Language," File No. 788, February 6, 1969.

(14) Wells, R. A., "A Performance Study of the System/360 Direct Access Storage Facilities at the University of Illinois," File No. 783, January 2, 1969.

(15) Yasui, T. and Winje, G. L., "Significant Digit Arithmetic on Illiac IV," File No. 789, February 18, 1969.

Report Numbers

(1) Baugh, C. R., Ibaraki, T., Liu, T. K. and Muroga, S., "Optimum Network Design Using NOR and NOR-AND Gates by Integer Programming," Report No. 293, January 10, 1969.

(2) Borovec, R. T., "The PAX II Picture Processing System at the University of Illinois Programming Manual," Report No. 314, March 18, 1969.

(3) Dunn, L. A., Lakshmi, N. G., McCormick B. H., and Tareski, Tareski, V. G., "Parametric Description of a Scan-Display System," Report No. 308, February 5, 1969.

(4) Esch, J. W., "A Display for Demonstrating Analog Computations with Random Pulse Sequences," Report No. 312, March 11, 1969.

(5) Ibaraki, T., Liu, T. K., Baugh, C. R., and Muroga, S., "An Implicit Enumeration Program for Zero-One Integer Programming," Report No. 305, January 6, 1969.

(6) Ibaraki, T., and Muroga, S., "Implicit Enumeration Algorithm of Integer Programming on Illiac IV," Report No. 319, January 20, 1969.

(7) Muroga, S. and Ibaraki, T., "Minimization of Switching Networks Using Negative Functions," Report No. 309, February 17, 1969.

(8) Northcote, R. S., "Software Development for the Array Computer Illiac IV," Report No. 313, March 12, 1969.

(9) "Quarterly Progress Report -- Illiac IV - October - December 1968," Report No. 316, February 1, 1969.

Theses

(1) Beals, A., "The Generation of a Deterministic Parsing Algorithm," (M.S.), Report No. 304, January 6, 1969.

(2) Bernott, B. A., "Disk I/O for Non-Core-Contained P.D.E. Meshes and Arrays," (M.S.), Report No. 311, March 5, 1969.

(3) Budnik, P. P., "Tranquil Arithmetic," (M.S.), Report No. 296, January 6, 1969.

(4) Dill, C., "A Computer Graphic Technique for Finding Numerical Methods for Ordinary Differential Equations," (M.S.), Report No. 295, January, 1969.

(5) Georgiou, C., "A Generalized Assembler," (M.S.), January, 1969.

(6) Heimerdinger, W. L., "String Processing on a Parallel Computer," (M.S.), Report No. 299, January 13, 1969.

(7) Irwin-Zarecki, M. P., "Nucleol as a Formal System," (M.S.), Report No. 310, February 21, 1969.

(8) Muraoka, Y., "Storage Allocation Algorithms in the Tranquil Computer," (M.S.), Report No. 297, January 13, 1969.

(9) Sand, D. S., " A Theoretical Analysis of the Modulation Characteristics of an Electro-Optic Light Valve," (M.S.), Report No. 303, January, 1969.

(10) Steiner, W. G., "Potentiomatrix -- A Novel Display System Possessing 'Innate Intelligence," (Ph.D.), Report No. 307, February, 1969.

(11) Trout, H. R., "A BNF Like Language for the Description of Syntax Directed Compilers," (M.S.), Report No. 300, January 13, 1969.

(12) Tummelson, J. M., "An Algorithm for Delay Checking Computer Designs," (M.S.), Report No. 301, January 13, 1969.

(13) Wilhelmson, R., "Control Statement Syntax and Semantics of a Language for Parallel Processors," (M.S.), Report No. 298, January 13, 1969.

11.3 Colloquia

"Lattice Functions, Pair Algebras and Finite State Machines," by Professor C. L. Liu, Project MAC, Massachusetts Institute of Technology, Cambridge, Massachusetts, January 6, 1969.

"Statistics Data Reduction Via Construction of Sample Space Partition," by Professor J. Bialasiewicz, Institute for Automatic Machines, Warsaw, Poland, January 13, 1969.

"Computer-Aided Logic Design on the TX-2 Computer," by Dr. Gary Hornbuckle, Lincoln Laboratories, Massachusetts I Institute of Technology, Cambridge, Massachusetts, February 3, 1969.

"The Use of Time Shared Computers for Data Retireval," by Dr. Joe Weir, Bell Telephone Laboratories, New Jersey, February 17, 1969.

"PLORTS Phase o--Timesharing on the 360/50," by Professor Neal Weidenhofer, Department of Computer Science, University of Illinois at Urbana-Champaign, Urbana, Illinois, February 19, 1969.

"Survey of Computational Complexity," by Professor J. Hartmanis, Department of Computer Science, Cornell University, Ithaca, New York, February 24, 1969.

"Analysis of Real Time Computer Networks," by Mr. Edward K. Bowden, Department of Computer Science, University of Iowa, Iowa City, Iowa, February 28, 1969.

"Operating System Structures," by Mr. P. D. Jones, Control Data Corporation, Massachusetts, March 3, 1969.

"Some Formal Properties of Transformational Grammars," by Mr. H. W. Buttleman, Department of Computer and Information Science, University of North Carolina, Chapel Hill, North Carolina, March 12, 1969.

"An Optimizing Compiler for an Extended Version of the Floyd-Evans Production Language," by Mr. H. R. Haynes, University of Texas, Austin, Texas, March 19, 1969.

"Least Squares, Singular Values, and Matrix Approximations," by Professor G. H. Golub, Stanford University, Stanford, California, March 24, 1969.

11.4 Drafting

During the first quarter, a total of 714 drawings were processed by both drafting sections:

	General	Pattern Recognition
Large Drawings	39	28
Medium Drawings	113	121
Small Drawings	120	99
Layouts	34	0
Report Drawings	30	0
Changes	66	3
Miscellaneous	61	0
TOTAL	463	251

(M. Goebel and J. Otten)

11.5 Shops' Production

Job orders processed and completed during the first quarter of 1961 are as follows:

	AEC 1018	AEC 1469	Other
Machine Shop	18	17	14
Electronics Shop	50	59	0
Chemical Shop	19	52	2
Layout Shop	12	44	4
TOTAL	99	172	20

Wiring of 446 printed circuit boards during this period accounted for 3,646 diodes, 770 transistors, and 563 integrated circuits.

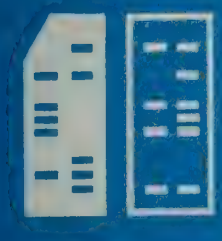
(F. P. Serio)

E66

COO-1469-0146
COO-1018-1190

QUARTERLY TECHNICAL PROGRESS REPORT

April, May, June 1969



DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN · URBANA, ILLINOIS

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QUARTERLY TECHNICAL PROGRESS REPORT

April, May, June 1969

Department of Computer Science
University of Illinois at Champaign-Urbana
Urbana, Illinois 61801

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract N000 14-67-A-0305-0007, W. J. Poppelbaum, Principal Investigator)

Summary

During this quarter RASCEL was completed and a final report was issued on this project (Department of Computer Science Report #332). A revised version of the large screen display project is described by Mehernosh Cooper and is called LASCOT (Large Screen Color Television). David Ring reports on BUM (Bundle Machine) which was formerly referred to as the Bundle Processing Project. He discusses the results of the feasibility model and the "Attrition Problem". Finally, a new project, COLOMATRIX (Color Matrix Display) is described by Stavros Hadjistavros.

W. J. Kubitz

for M. Faiman

1.1 RASCEL (Regular Array of Stochastic Computing Element Logic) Project No. 3

This project is now complete. Persons wishing information on this project should obtain Report Number 332, - RASCEL - "A Programmable Analog Computer Based on a Regular Array of Stochastic Computing Element Logic", by John Esch from the Department of Computer Science, University of Illinois at Urbana - Champaign, Urbana, Illinois, 61801.

1.2 LASCOT (Large Screen Color Television) Project No. 9

The LASCOT system provides a means for displaying television pictures in color on a large screen at reasonable cost. Figure 1 illustrates the proposed system. A brief description of the components as shown in Figure 1 follows.

1.2.1 Scanning System

The LASCOT system will be capable of displaying a color television picture by scanning it directly from a color television receiver. Vibrating galvanometer mirrors will be used to accomplish the scanning. Because mirrors are used, the picture must be scanned from the receiver with a scanning pattern which differs from that of the receiver. The deflection voltage waveforms will be triangular rather than sawtooth. The vertical deflection mirror will have a frequency response of 0-1000Hz so as to include as many odd harmonics as possible. The horizontal deflection mirror will have a frequency response of 0-25kHz so as to include the fundamental and the third harmonic of the triangular wave.

1.2.2 Detection

The scanned illumination will be passed through optical filters in order to separate it into its blue, green and red components.

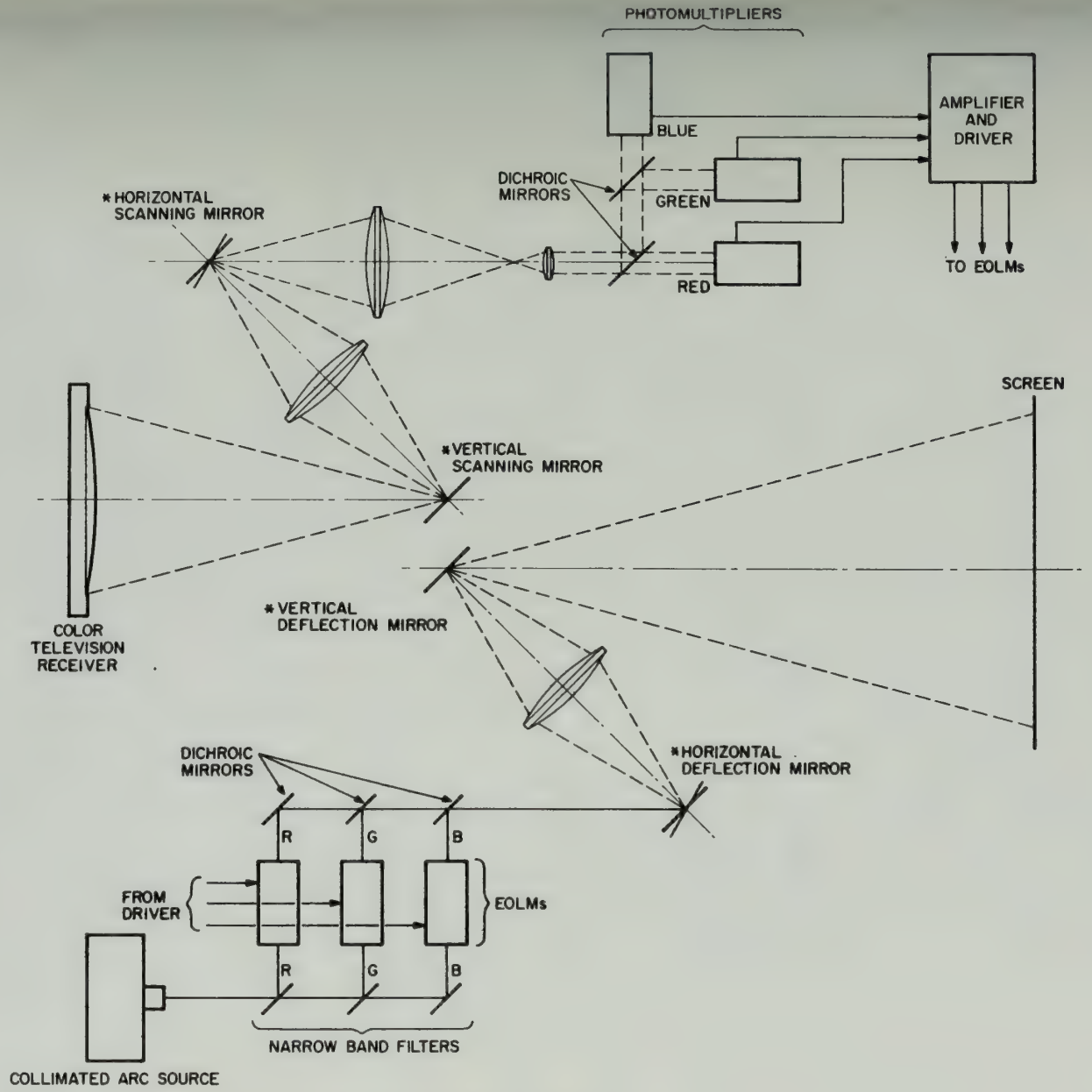


Figure 1. Large Screen Color Television.

The outputs of the filters will be detected by photomultiplier tubes having appropriate spectral responses. The outputs of the photomultiplier tubes, after amplification, will be used to drive the electro-optic light modulators (EOLMs).

1.2.3 Projection System

The light source to be used is a Xenon arc lamp. The output of the source will be directed through three narrow band interference filters in order to produce separate red, green and blue sources. The outputs from these filters will be fed to the corresponding EOLMs which receive their modulating voltages from the amplifier of the photomultiplier tubes.

The modulated light beams will be recombined by dichroic mirrors and then directed to the deflection system which is similar to the scanning system.

M. N. Cooper

1.3 BUM (Bundle Machine) Project No. 21

1.3.1 Summary

A portion of the Bundle Processing Machine has been built and demonstrated. A few small problems arose and will be corrected. The "Attrition Problem" (described in the previous Quarterly Technical Progress Report [QTPR]) was investigated but no solution was found, at least for the approaches taken as of this date.

1.3.2 The Constructed Portion of BUM

As described in the previous QTPR, a machine was to be built to demonstrate the feasibility of Bundle Processing. Because of limited time, only the multiplier section of the feasibility model was built. This multiplier section was completed and successfully demonstrated. The multiplier has since been dismantled and is being incorporated into the final version of the machine. Two problems were observed during the demonstration and will be corrected. First, the light bulbs used had a very short life. Longer life bulbs have been substituted. Second, ground loops caused interaction between the inputs; changing the value of one input also changed the value of others. More careful construction of the power distribution system should eliminate this problem.

The final version of the machine is nearing completion. It is anticipated that power can be applied in mid-July.

1.3.3 The "Attrition Problem"

In all schemes used for addition (and therefore subtraction also) the result has been scaled by a factor of $\frac{1}{2}$. It is desired to find a method of adding that does not scale and at the same time maintains the fail-soft feature. Of course, one could simply count all of the wires at the "1" level, multiply that number by two, and set that number of output wires to "1". This scheme, however, does not preserve the fail-soft feature. That is, failure of the counter or multiplier leads

to failure of the entire process. In the interests of solving this problem, two classes of solutions have been suggested. One has been examined fully and the other is being examined. These two solutions are considered below.

1.3.3.1 Boolean Functions of Two Variables

In this proposed solution the wires of the input bundles are paired (at random) - one wire from each bundle - until all wires from both bundles are used. Each pair is used as the input to a two-input combinational logic circuit, and each circuit's output becomes one wire of the output bundle. Thus, for bundles having 100 wires, 100 identical combinational circuits are required. By evaluating the 16 possible boolean functions any useful outputs can be determined.

This machine uses the mapping $x = \frac{1+y}{2}$ where x is the ratio $\frac{\text{wires at "1"}}{\text{wires in bundle}}$, and y is the number being represented.

$$0 \leq x \leq 1 \qquad -1 \leq y \leq +1$$

Consider the boolean operations: $\wedge$ (AND), $\vee$ (OR), and - (NOT). Given two inputs x_1 and x_2 with probabilities of occurance in the range [0,1], the above operations on these inputs yields the following results:

$$\bar{x}_1 \qquad \rightarrow \qquad 1 - x_1$$

$$x_1 \wedge x_2 = x_1 x_2 \qquad \rightarrow \qquad x_1 \cdot x_2$$

$$x_1 \vee x_2 \qquad \rightarrow \qquad x_1 + x_2 - x_1 \cdot x_2$$

If x_1 and x_2 are disjoint, then $x_1 \wedge x_2 = 0$, $x_1 \cdot x_2 = 0$ and $x_1 \vee x_{2_{disj}} \rightarrow x_1 + x_2$.

All possible boolean functions of two variables can be expressed as follows:

$$X = f(x_1,x_2) = a_1x_1x_2 \vee a_2x_1\bar{x}_2 \vee a_3\bar{x}_1x_2 \vee a_4\bar{x}_1\bar{x}_2$$

where the coefficients $a_i = \{0,1\}$. For any one combinational circuit at any particular time the four terms are disjoint from each other. Substituting in the probabilities over a large sample gives:

$$X = a_1 \cdot x_1 \cdot x_2 + a_2 \cdot x_1 \cdot \bar{x}_2 + a_3 \cdot \bar{x}_1 \cdot x_2 + a_4 \cdot \bar{x}_1 \cdot \bar{x}_2 .$$

If $x = \frac{1+y}{2}$ and $\bar{x} = (1-x) = \frac{1-y}{2}$, then

$$\frac{1+Y}{2} = a_1(\frac{1+y_1}{2})(\frac{1+y_2}{2}) + a_2(\frac{1+y_1}{2})(\frac{1-y_2}{2}) + a_3(\frac{1-y_1}{2})(\frac{1+y_2}{2}) + a_4(\frac{1-y_1}{2})(\frac{1-y_2}{2})$$

or finally

$$X = \frac{1}{2}[a_1(1+y_1)(1+y_2) + a_2(1+y_1)(1-y_2) + a_3(1-y_1)(1+y_2) + a_4(1-y_1)(1-y_2)] - 1$$

By evaluating Y for all sixteen combinations of a_i, the possible values can be determined.

Table 1 clearly shows that no two-input combinational circuit produces addition. It is also clear that multiplication can be performed with a coincidence circuit. This was the method used in the feasibility machine.

a_1	a_2	a_3	a_4	Y	TYPE
0	0	0	0	-1	
0	0	0	1	$\frac{1}{2}(-1-y_1-y_2 + y_1y_2)$	NOR
0	0	1	0	$\frac{1}{2}(-1-y_1+y_2 - y_1y_2)$	
0	0	1	1	$-y_1$	
0	1	0	0	$\frac{1}{2}(-1+y_1-y_2 - y_1y_2)$	
0	1	0	1	$-y_2$	
0	1	1	0	$-y_1y_2$	EXCLUSIVE OR
0	1	1	1	$\frac{1}{2}(1-y_1-y_2 - y_1y_2)$	NAND
1	0	0	0	$\frac{1}{2}(-1+y_1+y_2 + y_1y_2)$	AND
1	0	0	1	y_1y_2	COINCIDENCE
1	0	1	0	y_2	
1	0	1	1	$\frac{1}{2}(1-y_1+y_2 + y_1y_2)$	
1	1	0	0	y_1	
1	1	0	1	$\frac{1}{2}(1+y_1-y_2 + y_1y_2)$	
1	1	1	0	$\frac{1}{2}(1+y_1+y_2 - y_1y_2)$	OR
1	1	1	1	$+1$	

TABLE 1.

1.3.3.2 Boolean Functions of Three or More Variables

This method will be more thoroughly investigated during the next quarter. In this approach, the wires of each bundle are numbered sequentially. Again each wire of the output bundle is the output of one of many identical combinational circuits but now each circuit looks at more than just a pair of wires. For example, the circuit for output wire n would look at input wires n, n-1, n-2, . . . to whatever accuracy is desired. Generally an increase in inputs produces an increase in complexity. If all the circuits use all of the wires in both input bundles, the output bundle will be accurate but the amount of circuitry for each output wire will be extremely large. Thus, it does not appear that this approach will yield a practical solution to the problem. In addition, for the mapping being used more than half or less than half of the wires are at "1" depending on the sign of the number being represented. This implies the need for a control wire telling each circuit the sign of the number. Any circuit that is used only once is not acceptable because its failure means failure of the entire system. This approach will be investigated in greater detail during the next quarter.

David Ring

1.4 Half-Order Approximation of Lines and Curves of Drawings for Bandwidth Compression Project No. 22

Work on this project has been stopped temporarily while other avenues of approach are being investigated.

1.5 COLORMATRIX (A Liquid Crystal Colored Matrix Display) Project No. 27

COLORMATRIX is a display system using the thermal properties of liquid crystals.

1.5.1 Liquid Crystals

Liquid crystals are substances which possess a mesophase between the solid, crystal-line state and the liquid, isotropic state. They exhibit anisotropic properties (such as optical rotatory power) which are characteristic of the crystalline material although they appear to be in the liquid state. They are further classified as SMECTIC, NEMATIC and CHOLESTERIC. The latter ones are cholesterol esters and under mesophase conditions, selectively reflect the various spectral components of white light. This phenomenon obeys approximately the Bragg diffraction relationship which suggests a structure of layers involving large spacings (0.2 - 0.8μm). The colored reflected light is a function of the structure of the liquid crystal and is changed with increasing temperature to the shorter wavelengths. The region of the visible spectrum covered depends on the chemical structure of the molecule. Using appropriate mixtures both the region of the visible spectrum which appears and the corresponding region of temperature at which a given portion of the spectrum occurs can be regulated.

1.5.2 The Display

The goal of the project is to construct an electronic display system in which the temperature of various small limited areas can be controlled by signals carrying the information to be displayed.

For a feasibility model, an array of transistors will be used; the heat dissipated by their base-collector junctions will be used to produce the appropriate areas of controlled temperature on the display. The base of the transistor is the control element for the displayed information.

1.5.3 Experimental Investigation

In order to proceed with the construction of the display, some devices were designed and constructed which can be used to determine the thermal properties of liquid crystals and transistors.

1. An electronic thermometer was constructed in order to determine the spectra of the liquid crystals versus temperature. A thermistor temperature sensor is used. The temperature range of this thermometer is 15 - 95°C. The resolution ≃1/50°C and the time constant, depending on the thermistor, ≃ 3 sec.

2. A heater was also constructed. Its temperature range is 25 - 65°C and its stability ± 0.1°C.

3. To study the thermal time constants of transistors (junction and case), a third device was constructed. The measurement of the thermal time constant of the base collector junction τ_j is based on the linear change (-2mv/°C) of v_{be} versus temperature. To measure the thermal time constant at the case, a temperature to current (or voltage) transducer must be used. Because (for small high frequency transistors) τ_j is of the order 2 - 3 msecs, fast transducers with time constants well below this limit are required. Appropriate types are bolometers and photoconductive or photovoltaic IR sensors. (time constants 1μs - 0.8μs) However, they are expensive. Therefore a device was built which can be used to simultaneiously measure both τ_j, the junction time constant and τ_c, the case time constant. τ_j is

measured by observing the v_{be} charge vs. temperature. This gives an upper limit for the possible thermal time constant of the transistor. τ_c is measured by determining the junction voltage of an external diode or the v_{be} of an external transistor. This diode or transistor must, of course, be very small so that its thermal time constant is small and, in addition, it must be in intimate contact with the transistor under test.

S. Hadjistavros

2. HARDWARE SYSTEMS RESEARCH

(Supported in part by the Atomic Energy Commission under Contract US AEC AT(11-1) 1469, W. J. Poppelbaum, Principal Investigator.)

Summary

Several topics concerning the OLFT system are described: Operation of the erase gun and experiments utilizing 5 mil thick crystals (Douglas Sand), the Alphecon storage system (Richard Ohran) and the use of color center crystals as a storage media (Chinlon Lin). The Delta Density Detector circuitry for VISTA is explained by David Rollenhagen. With regard to ORBIT, work on the "horizontal line problem" and checkout of the A/D converter is progressing (Pete Oberbeck). Some possible improvements to the Tricolor Cartograph are described by Donald Hanson. A pattern recognition scheme has been developed for TRANSFORMATRIX (Larry Ryan). Yiu Wo discusses the TRANSFORMATRIX raster generation scheme used for displaying the discrete Fourier transform. The cameras and the monitor for the BLAST system (formerly 3D television) have been received and a request for quotes on the special cathode ray tube has been sent out (Larry Wallman). Finally, work on the STEREOMATRIX Position Sensor has begun (Charles Pirnat). Progress on the Coefficient Generator is reported by Richard Cheng. A block diagram of the Transformer is explained by Shiv Verma and several of the problems encountered with the Display are discussed by Steve Whiteside.

W. J. Kubitz for M. Faiman

2.1 OLFT (On-Line Fourier Transform System) Project No. 12

2.1.1 General Progress

The erase gun has now been operated enough that a number of conclusions may be drawn based on experience. These are discussed in section 2.1.2. In general, the erase pulse can significantly improve the resolution and lag characteristics of the picture but certain problems must still be overcome. The Alphecon subsystem -- to be used for temporary single-frame storage -- has been constructed in prototype form and is discussed in section 2.1.4. Crystals polished to a thickness of 5 mils have been obtained and partially tested for resolution and picture quality. This is discussed in the next section. Finally, a study of color center crystals has been made and is reported on in section 2.1.5.

2.1.2 Test Results Using 5 mil Crystals

Some significant results have been obtained using the crystals polished to 5 mil thickness. Using coherent laser light the picture is severly degraded by strong fringe patterns resulting from reflection at the several interfaces of the target assembly. These interfaces exist between the target materials, consisting of KDP or KD*P, a conducting film of CdO, glue, and a substrate of CaF. These materials were selected for thermal and mechanical compatibility, and an optical match would require and anti-reflection coating at each interface. However, from brief tests using incoherent light (from a tungsten-source monochromator) it is evident that a 5 mil crystal can provide resolution comparable with that of commerical television (180 line pairs) if the erase gun is used to reduce charge spread across and through the crystal. Unfortunately, the 5 mil crystal exhibits strong stress birefringence since a crystal this thin is easily warped. Warping is possibly caused by an uneven expansion of the target glue during vacuum pump-down and/or by an uneven temperature distribution over the crystal surface during operation. This uneven stress birefringence gives a natural polarization bias to the transmitted picture which then contains bright, unmodulated patches. These results indicate that the target assembly must be modified in a number of ways so that 5 mil crystals may be used in normal operation.

2.1.3 Erase Gun Operation

The erase gun and associated circuits -- discussed in previous quarterly reports -- perform reasonably well but the results of several hours of operation suggest some improvements which may increase the effectiveness and reliability of the erase operation.

The erase gun pulse of about 1 msec every field can effectively erase the write-gun charge pattern, subject to some qualifications. First, a zero-voltage erase bias is obtained for a cathode potential of about 1500 volts. This limits the maximum erasable surface potential. At the present time this is no difficulty since the write guns used cannot deposit surface potentials much beyond that. Second, the secondary emission characteristics and resistiveity of the crystal appear to be quite temperature dependent. This means that a stable operating condition is difficult to maintain (especially if the picture changes rapidly, as in live television). Finally, the resulting erase bias is occasionally "patchy" causing bright, uniform areas with distinct boundaries to appear, growing or shrinking as conditions change. This phenomenon, which is unrelated to the stress birefringence mentioned in the preceding section, may possibly be caused by non-uniformities in surface characteristics. It is evidence of the bistable nature of the secondary emission process. (That this is the case may be seen by recalling that at equilibrium the surface potential is either the cathode potential $-V_K$, or $(V_{II} - V_K)$, where V_{II} is the second crossover potential of the secondary emission curve of the crystal.) However, when the erase gun is performing well, picture resolution and lag are significantly improved. Thus, various modifications are being considered to minimize the undesirable features so far associated with erase gun operation.

First, crystals with surface coating, such as silicon dioxide, will be tested. A surface coating (either vacuum deposited or sputtered) has known characteristics, and would be much more uniform than the thin crystals which are, of course, just a cross section of a very large, slowly grown crystal. In addition, the surface coating will be made into an anti-reflection coating which will help reduce the fringing discussed in the preceding section.

Second, different collector grid configurations will be tried. At present, a simple wire ring surrounds the circumference of the crystal

and is held at a potential of about 200 volts. This ring has little effect on the center of the crystal and may lead to some of the non-uniformity discussed earlier. A better configuration would be a fine metal mesh parallel to the crystal surface. Primary electrons from the erase gun cathode would pass through the mesh to the crystal surface, but secondary electrons from the crystal surface would see only the collector mesh so that the equilibrium potential would essentially be the mesh potential. This collector mesh must be located near the crystal surface and would thus be in the optical path. However, the mesh-pattern image which would have a very high spatial frequency relative to the spatial frequency content of the television picture could be removed by a suitable static spatial filter.

These modifications may prove sufficient and will at least increase the known characteristics of the operation of the erase gun.

Douglas Sand

2.1.4 Alphecon - Storage System

A storage system has been constructed to retain for continuous readout the information of one standard TV frame. The system is based upon the Alphecon, a developmental electrostatic storage tube purchased from RCA. Utilizing vidicon-like sweep circuitry, the video information is recorded on the target of the Alphecon with electron bombardment of sufficient potential to cause a secondary emission ratio greater than unity. This produces a positive charge distribution on the target. Continuous readout for two or more minutes is performed with electrons of a potential which produces a unity secondary emission ratio. Erasure of the charge "image" is done by a defocused beam of electrons at low energy levels. Therefore single-frame storage with good resolution has been deomonstrated but some difficulties have been encountered. In particular, the adjustment of grid and target voltages seems quite

critical for an optimal combination of write time, erase time, and picture quality. These voltages are controlled by seven interacting potentiometers and, in addition, exhibit temperature dependence. At present the electronic package is being rebuilt to reduce some of the cited difficulties and to incorporate additional improvements such as higher bandwidth video amplifiers and more flexible control logic for the erase-write-red cycle. So far, the system has produced 300 television lines of resolution.

R. Ohran

2.1.5 Color Center Crystals for Information Storage

One application of the OLFT system is spatial filtering. The fundamental idea of spatial filtering is to mask out certain portions of the frequency plane representation of an incoming picture. A future project utilizing the system involves the on-line creation of the spatial filter as well as the spectrum in order to accomplish adaptive spatial filtering. Color center crystals have been suggested as one possible material which might be used for this purpose. This possibility has been examined. The investigation concentrated on the applications of color center phenomena to information storage. A color center is a lattice defect in a crystal which is capable of absorbing visible light and upon doing so becomes colored. For example, pure alkali halide crystals are transparent throughout the visible region of the spectrum. However, if a NaCl crystal is heated in sodium vapor it will become yellow; if a KCl crystal is heated in potassium vapor it will become magenta. These phenomena are due to the presence of color centers. The presence or absence of color centers with their associated absorption bands can be used for information storage. However, to be practical the photochemical conversion process must be completely reversible.

Many color center crystals have been investigated experimentally

and their theoretical models established. For information storage purposes the color center conversions $U \rightarrow R$, $F \longleftrightarrow F'$, $F \longleftrightarrow F_A$ and the anisotropy of M_A center phenomonon appear to be particularly attractive. Although information of a theoretical nature on the properties of color centers is abundant, little of it is devoted to the information storage aspects. From the references available the following information has been obatined:

(a) U → F center conversion: Reversible only by raising the temperature to above 600°C but not optically reversible and therefore not practical.

(b) F ⟷ F' Center conversion: Theoretically, the illuminating light needed is in the visible region and the operating temperature is liquid nitrogen temperature. However, since the F' band is a broad band which overlaps the F band and is thus not well defined, this might present a problem. There is no current literature on the use of this phenomenon for information storage and thus the possible difficulties are unknown.

(c) $F \longleftrightarrow F_A$ center conversion: Theoretically the operating region is visible light and room temperature. A possible difficulty here is the fatigue problem. That is, color centers will be lost since other competing processes are present. All other information is unknown at present.

(d) Anisotropy of M_A centers in alkali halide crystals: The possibility of binary storage has been investigated by the Naval Research Laboratory. For analog storage no experiment has been reported. The necessity of using two different light sources and maintaining the crystal at low temperature (77°k) may present some difficulties. However, this phenomenon is the center of current interest in digital information storage using color center properties.

It would seem that phenomena (c) and (d) could be investigated experimentally in connection with the OLFT system. However, at present, the information available is not adequate to predict promising results.

C. Lin

References for 2.1.5

(1) J. H. Schulman and W. D. Compton: "Color Centers in Solids", Pergamon, 1962.

(2) J. J. Markham, "F-centers in Alkali Halids", Solid State Physics, Supplement 8, Academic Press, 1966.

(3) Irwin Schneider (Naval Research Laboratory, Washington, D.C.) "Information Storage Using the Anisotropy of Color Centers in Alkali Halide Crystals", Letter, Applied Optics, December, 1967, Vol. 6, No. 12, p. 2197.

2.2 VISTA Project No. 14

2.2.1 Delta Density Detector

The delta density detector design has been completed. The central component of the delta density detector, as shown in the block diagram in Figure 1, is the video disc recorder. During each fast scan mode of operation the video signal originating in the camera is simultaneously stored and compared with the video signal which was recorded during the previous fast scan. This comparison of video signals eventually leads to a measure of the amount of information which changes between successive fast scans. The disc control shown in the figure shunts the video signals between three of the four tracks on the recorder. The fourth track is not used, and a fifth track provides synchronization signals for the entire system. Figure 2 illustrates the disc video control which comprises a modulo 3 counter, a decode section and a series of video gates. The modulo 3 counter changes state each time the system reverts to the fast scan mode. During this time the decode AND elements are activated. Depending on the particular count, one each of the erase, read and write gates will open to permit passage of the corresponding signals. Each time the count changes, a different set of three gates will open, thus permitting the read, write and erase signal among the three tracks.

The two signals to be compared arrive at the compare and hold circuit illustrated in Figure 3. The signals are of opposite polarity and pass through a normalization and buffer stage whereupon they are added at the operational amplifier. The resulting signal is rectified to provide a positive voltage in the event that the difference is negative. Thus the absolute value of the signal difference is realized. Diodes D_1 and D_4 are included in a unique arrangement to insure that the rectified current through R in the bridge is precisely equal to the difference current through R in the feedback loop. This being true, the voltage drop across D_1 exactly equals that across D_6 when the operational amplifier output is positive and D_2 and D_6 are forward biased; the voltage drop across D_4 exactly equals that across D_5 when the operational amplifier output is negative and D_3 and D_5 are forward biased. Moreover, the diodes are temperature compensated, each being a member of a six-diode array.

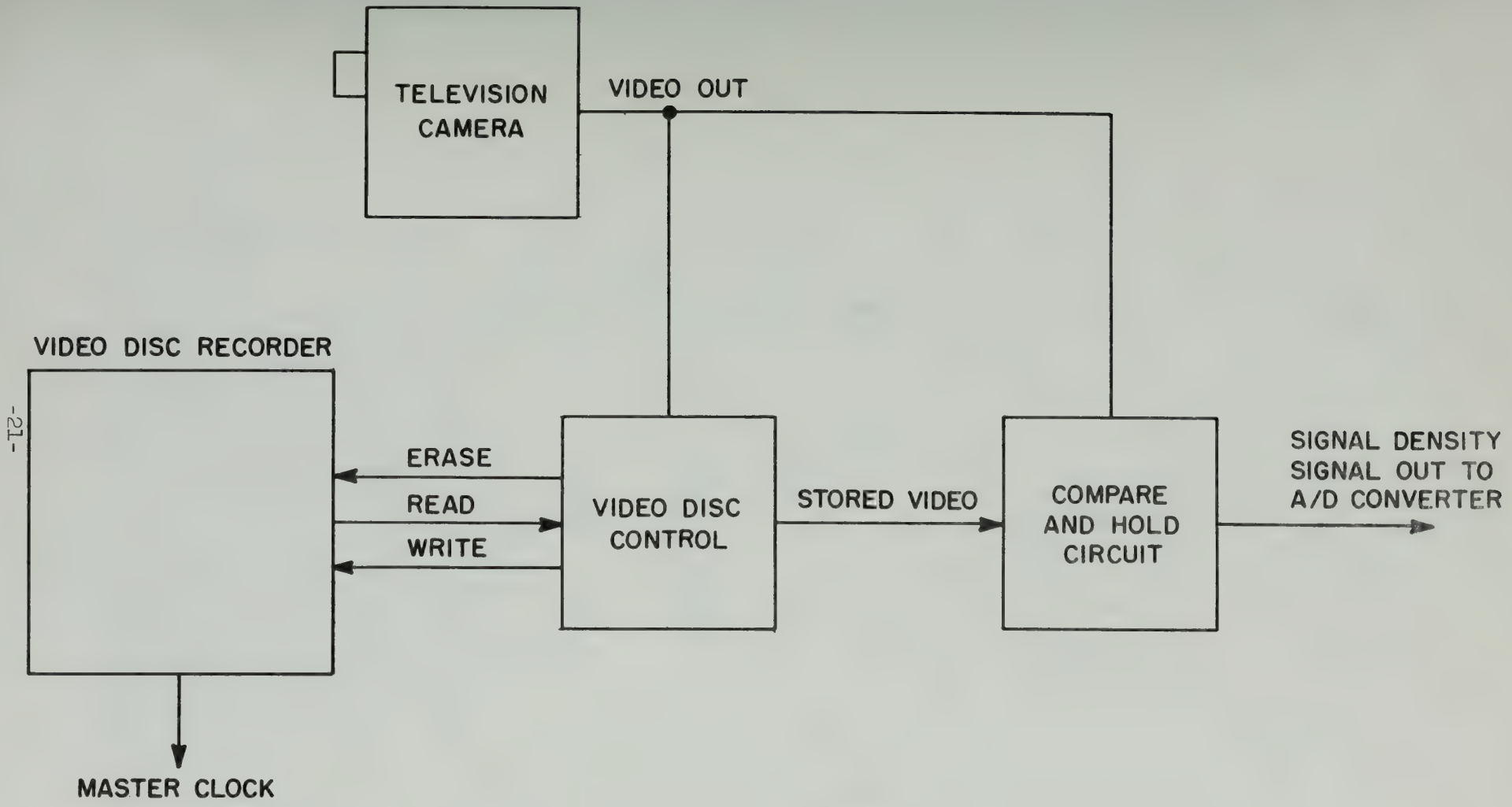


Figure 1. Block Diagram of Delta Density Detector

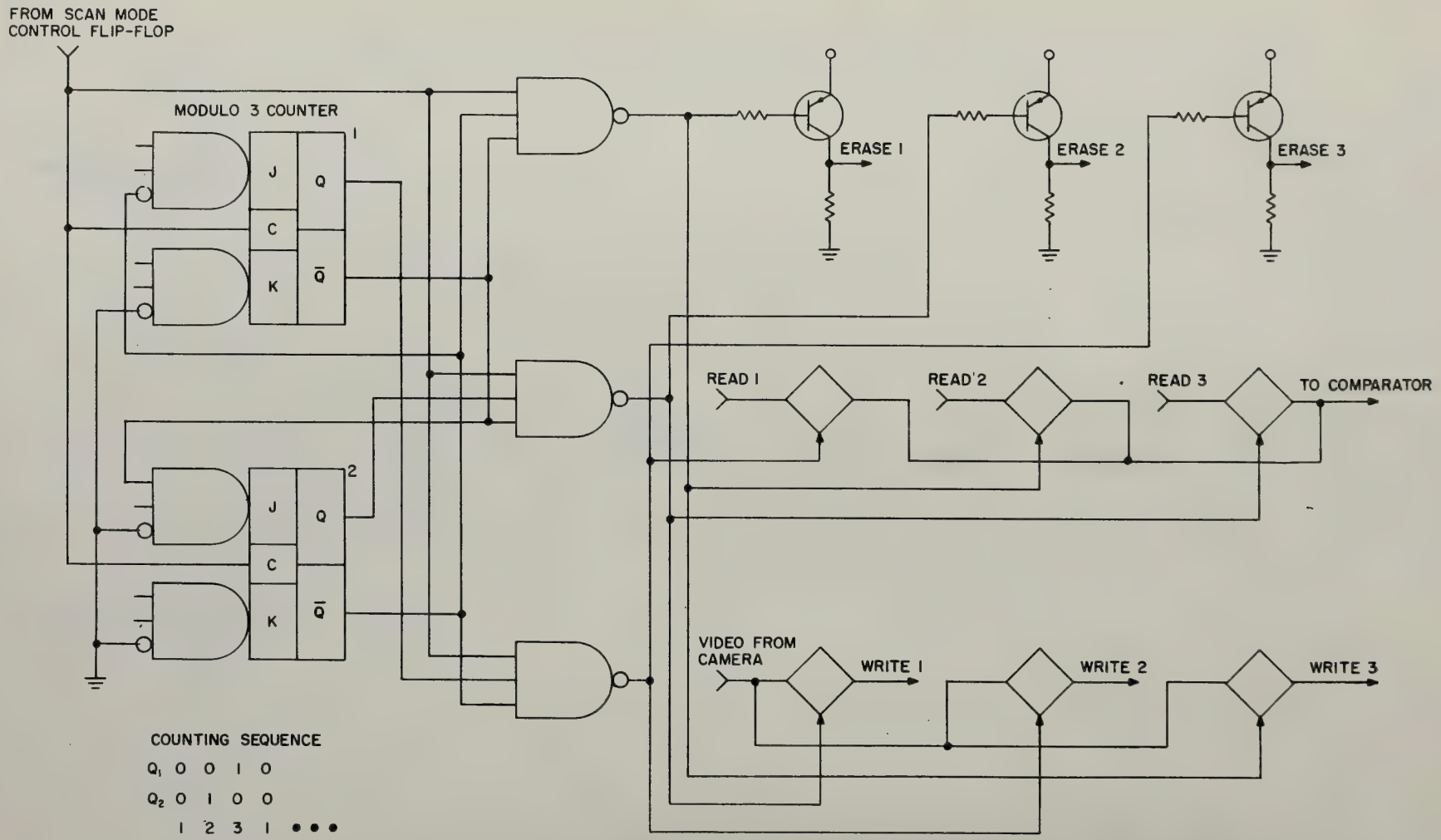


Figure 2. Disc Video Control

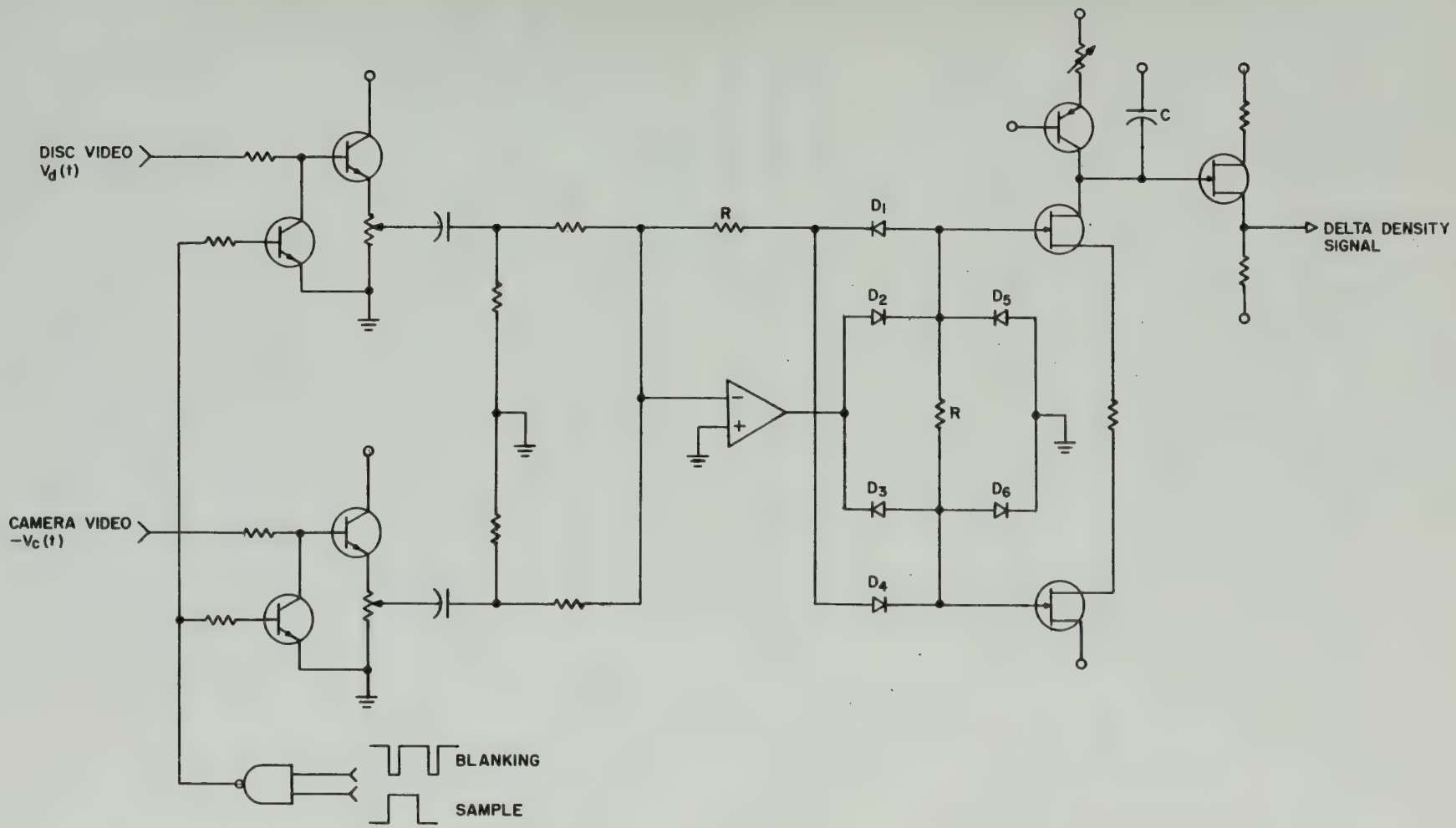


Figure 3. Compare and Hold Circuit

The magnitude of the difference voltage appearing across R of the bridge is detected and integrated by virtue of the field effect transistor arrangement which follows. The shifting nature of the voltage difference dictated the choice of this arrangement. In addition, the high impedence input to the complementary field effect pair prevents undesireable offset currents from appearing at the bridge. The bias current for this pair is supplied by the transistor current source. Any non-zero voltage across R results in a charging current through C. For small signal voltages across R, the resulting voltage across C will be

$$\int_0^T |v_d(t) - v_c(t)|\,dt$$

The video signals are attenuated at the input to the operational amplifier to insure that the linear range of the field effect transistors is not exceeded. The last field effect stage is a high impedence readout amplifier.

A gating voltage is applied at the input to the compare and hold circuit so that no comparison is made during the blanking period (since the blanking voltages may be unequal) or during the slow scan mode. The voltage across C, representing the delta density signal, will thus be stored during these intervals. The gating voltage cuts off the two input buffer transistors simultaneously, resulting in zero volts at the operational amplifier input when the digital output of the NAND gate is a logical "1".

D. Rollenhagen

2.3 ORBIT Project No. 15

Work on the horizontal line transmission problem and check-out of the A/D converter is progressing.

P. Oberbeck

2.4 Tricolor Cartograph Improvements Project No. 16

The areas of improvement to be made on the Tricolor Cartograph have been defined as follows:

1) Light pen and outline problem
2) Solid-color horizontal line problem
3) Shades of gray problem.

The outline problem is that of attempting to make a "hole free" outline for the Tricolor Cartograph. An improved light pen has been built and appears to be more sensitive, but even so, it still leaves gaps or holes in the outline. For this reason, the possibility of writing the outline on a piece of paper in front of a television camera will be investigated. There are some difficulties. The outline write circuitry must be changed to allow for a television camera's form of input. The most difficult problem is perhaps that of converting the video signal to a logic form so that it may be used to trigger the disc writing circuitry. This is difficult because the television camera's lens and target characteristics combine in such a way that curvature in the video field results. Hence, if a threshold detector is used, the threshold level will have to vary as a function of time. At present, writing directly onto the disk will be attempted to see if this will yield suitable results.

The second improvement which will be attempted is to produce solid color horizontal lines. At present, horizontal lines are chopped before storage, giving the figure a straiated appearance. Solid coloring may be accomplished by changing to a binary recording scheme and simply setting and resetting a flip-flop at the beginning and end of

the colored portion of each horizontal line. However, this is in conflict with recording shades of gray -- analog recording. Thus, some other scheme will be required if shades of gray are to be stored.

Gray level storage is the third problem. The disc is supposedly capable of four or so gray levels and thus gray level storage should be straightforward. There is some question, however, as to the linearity of the disc read and write circuitry.

D. Hanson

2.5 TRANSFORMATRIX Project No. 17

2.5.1 Pattern Recognition

It has been decided to incorporate a third feature into TRANSFORMATRIX. In addition to performing the Coordinate Transform and the Fourier Transform of the input picture, TRANSFORMATRIX will be capable of recognizing any 5 x 5 subsection of the 32 x 32 input pattern (grey scale = 2) and indicating its spatial location within the input pattern. This is accomplished by having a 5 x 5 array of selector switches on the computer console each of which can be set to any one of the coefficients (-1, -.9, -.8, . . ., 0. . . . .8, .9, 1). For each output point (k,ℓ), the processor enters the 5 x 5 coefficient array that has been selected symmetrically about column k and row ℓ of the $b_{k\ell ij}$ coefficient matrix. All other $b_{k\ell ij}$ coefficients are set equal to zero. This scheme is shown in Figure 1.

The values of the coefficients in the 5 x 5 array are chosen such that the sum of the products of the 5 x 5 coefficient array times the 5 x 5 subsection of the input pattern that is to be recognized is a maximum. The selection of approporiate coefficients is illustrated in Figure 2 for the letter "P". The coefficients corresponding to light dots in the "P" are set = 1 and the coefficients corresponding to dark (no light) dots are set =-.9. The negative coefficient is

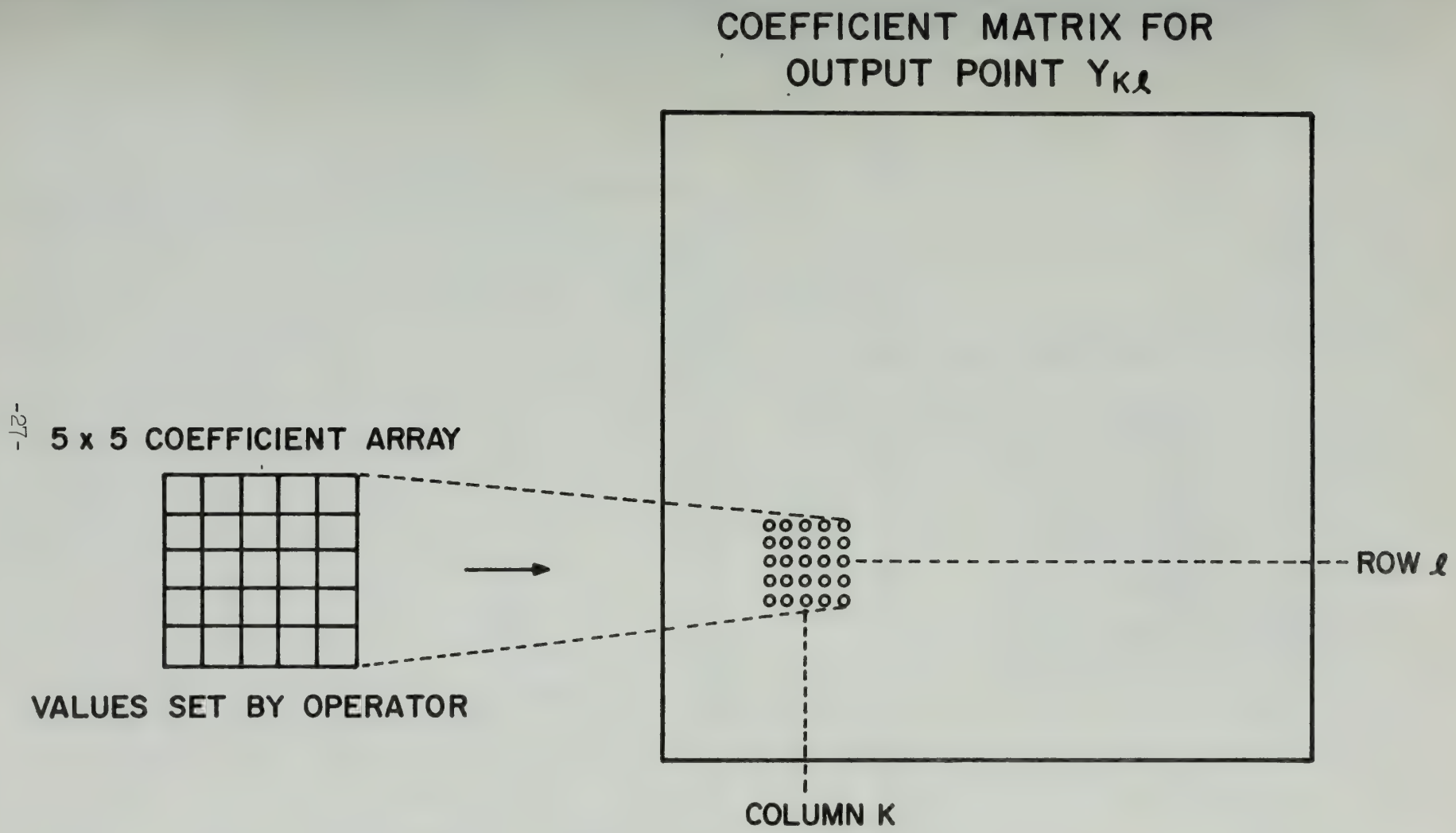
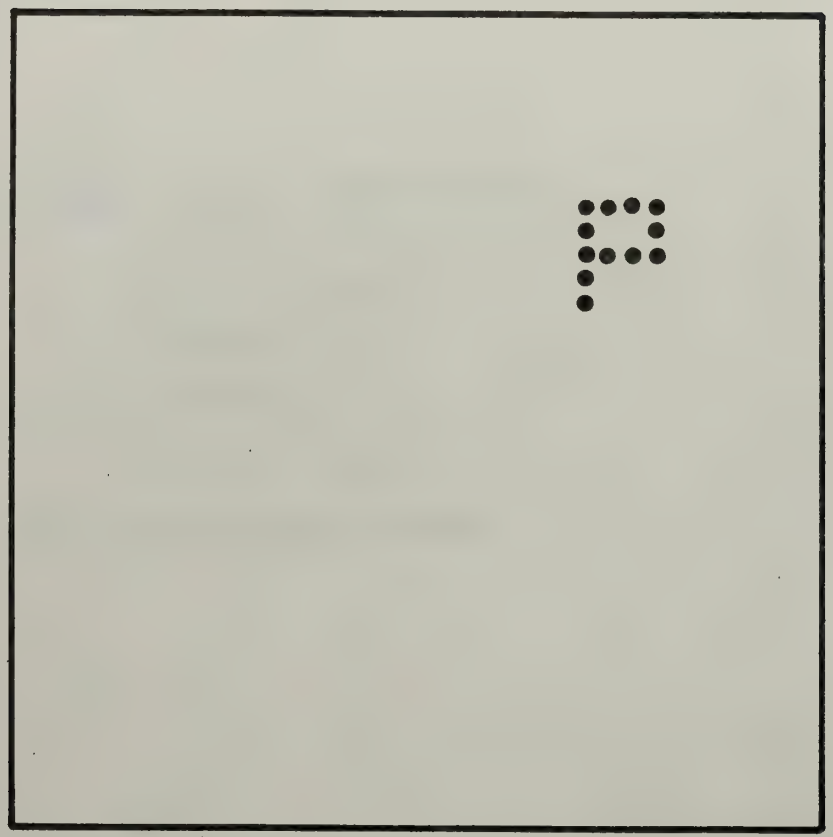


Figure 1. Position of 5 x 5 Coefficient Array within $b_{k\ell ij}$ Coefficient Matrix

INPUT PATTERN



5 x 5 COEFFICIENT ARRAY

1	1	1	1	-.9
1	-.9	-.9	1	-.9
1	1	1	1	-.9
1	-.9	-.9	-.9	-.9
1	-.9	-.9	-.9	-.9

FOR DETECTING THE LETTER 'P'

Figure 2. Selection of Coefficients

determined from the condition Σ coefficients = 0. This insures that light dots which make up the "P" and spurious light dots will be given weights in proportion to the number of light and dark dots in the pattern to be recognized. The output pattern that results from a "P" in the input pattern and a 5 x 5 coefficient array as described above is illustrated in Figure 3. Only output values ≥ 0 are shown.

Lawrence Ryan

2.5.2 Raster Generator for Displaying the Discrete Fourier Transform Output

As mentioned previously, the discrete Fourier transform which TRANSFORMATRIX is capable of performing is given mathematically by

$$F(m,n) = \frac{1}{32} \sum_{k,\ell=0}^{31} f(k,\ell)\exp\left[-2\pi i \frac{(km + \ell n}{32}\right] \qquad (1)$$

$$k,\ell = 0,1,2. \ . \ .31$$
$$m,n = o,1,2. \ . \ .31$$

In general, $F(m,n)$ is a complex quantity. One way of displaying this quantity, the method used by TRANSFORMATRIX, is to show any one of the three quantities $|F(m,n)|$, $|\mathrm{Re}F(m,n)|$, or $|\mathrm{Im}F(m,n)|$. The transformation process can be done more effectively by making use of some properties of the discrete Fourier transform. Following directly from the definition given by (1), one can easily find that

$$F^*(m,n) = F(32-m,\ 32-n) \qquad (2)$$

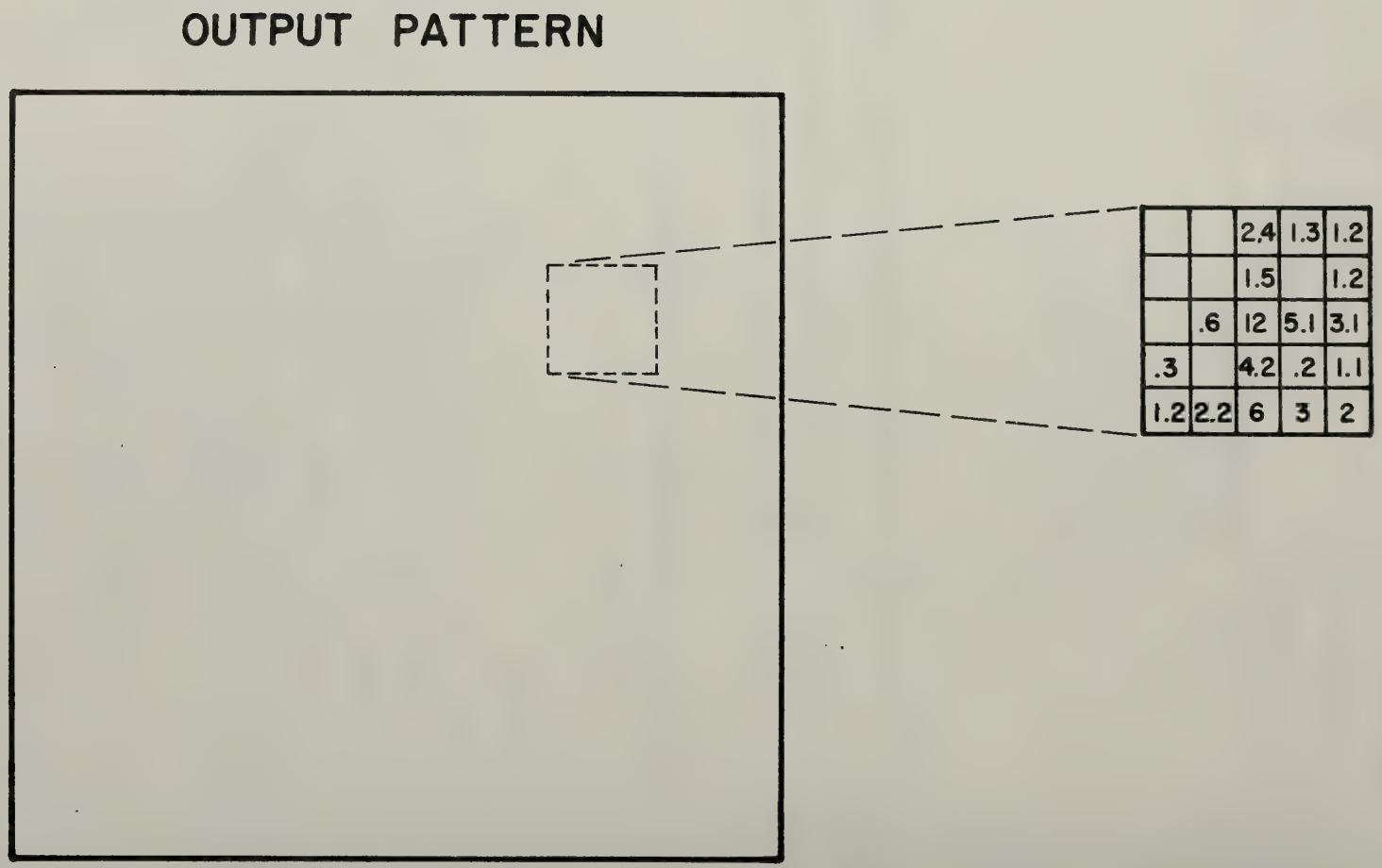


Figure 3. Output Pattern for 'P' in Input Pattern

It follows that

$$
\begin{aligned}
|F(m,n)| &= |F(32-m,\ 32-n)| \\
|REF(m,n)| &= |ReF(32-m,\ 32-n)| \\
|ImFe(m,n)| &= |ImF(32-m,\ 32-n)|
\end{aligned}
\tag{3}
$$

Thus, once the output at the coordinate m,n has been calculated, it can also be used for the output at (32-m),(32-n). Close examination of equation (1) shows that all but four points of the output picture have corresponding points as determined by (3). These four points are (m=0, n=0), (m=0, n=16), (m=16, n=0) and m=16, n=16). Therefore, the total number of output calculations is these four points plus one half of the rest. This reduces the calculation time to almost one half of that which would otherwise be required.

To display the full transformed output, however, the output network is required to have the following special features. Whenever an output F(m,n) and its coordinates (m,n) are sent from the processor to the output display network which consists of a cathode ray tube and its driving and blanking circuitry, the beam is steered first to position m,n. It stays there for one half clock period and then moves to location (32-m), (32-n) and remains there for the duration of the clock period. During this entire period, the intensity of the beam is held at the value F(m,n) which is common to both output points. Whenever one of the four odd points is encountered, a special blanking pulse is triggered to blank out the beam during half of the clock period.

The circuit described below is used for steering the beam from a point to its equivalent point related by equation (3). Actually, two of these circuits are used; one for the coordinate m and the other for coordinate n. Since they are the same in operating principle, the following explanation considers only the circuitry for coordinate m.

Figure 4 shows the logic of the circuit. The inputs x_1, x_2, x_3, x_4, and x_5 represent the coordinate m as a 5 bit binary number.

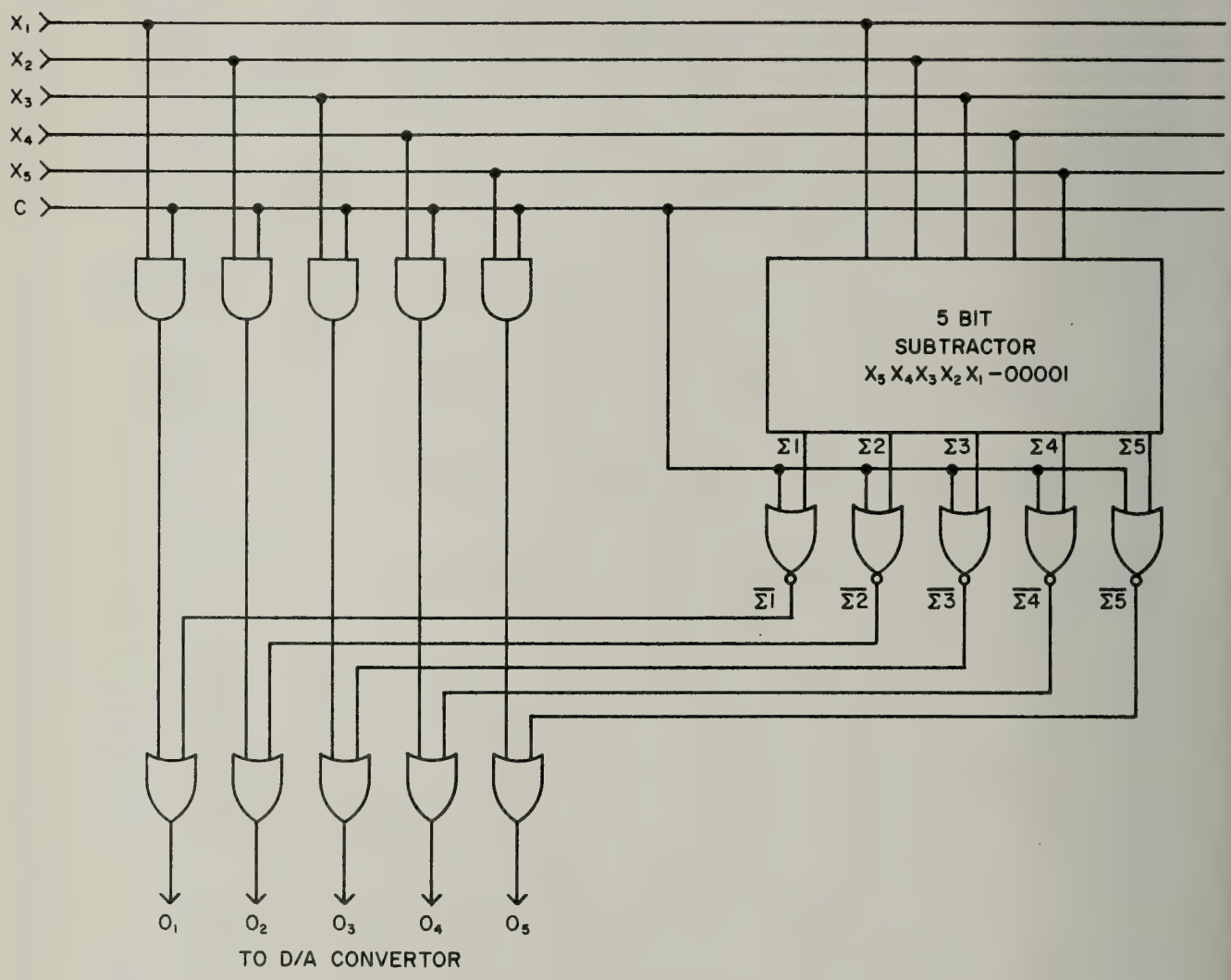


Figure 4. Pattern Generator Logic

c is the clock -- about 16kc. When the clock is a "1", the inputs are gated directly to the outputs o_1, o_2, o_3, o_4, and o_5. When the clock is a "0", the outputs are obtained from the negation of the output of the 5 bit parallel subtractor. At this subtractor, the binary number 00001 is subtracted from x_5, x_4, x_3, x_2, x_1.

This output gives the number (32-m) as a 5 bit binary number when the input is m and the clock is at "0". From Figure 4, it can be seen that when any one of the four odd points is encountered, the outputs o_1, o_2, o_3, o_4, o_5 remain unchanged for the entire clock period. For these cases the beam is blanked during the second half of the clock period so that the average amount of light produced at these points is the same as for all others.

Figure 5 shows the actual implementation of the logic shown in Figure 4.

Yiu Wo

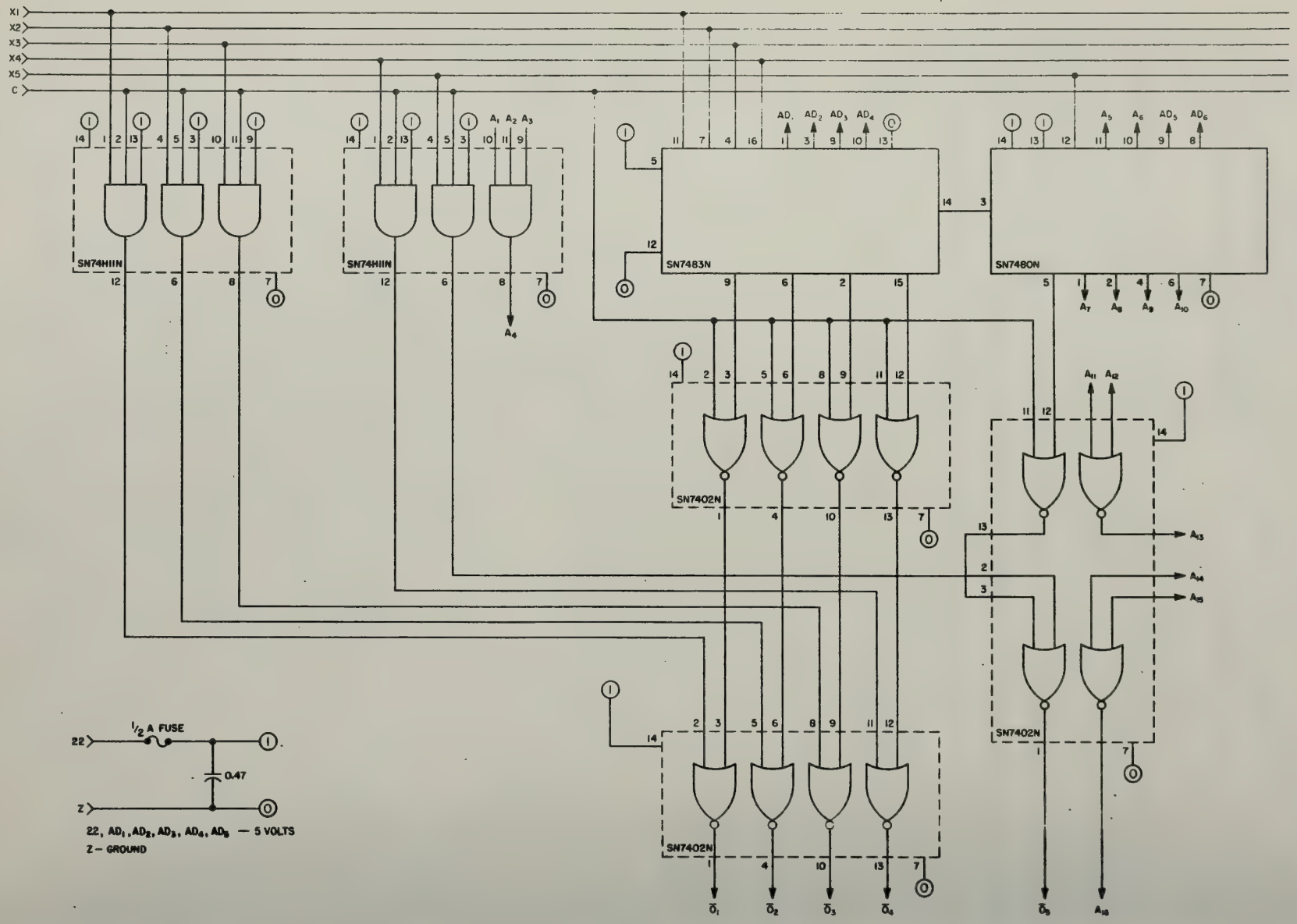


Figure 5. Actual Circuit of the Raster Generator for Displaying the Fourier Transform Output

2.6 BLAST Project No. 19

The 3-D television system has been renamed BLAST (Binocular Lenticular Automatic Stereo Television). The pair of television cameras have been received from Cohu Electronics. These cameras have been mounted on a specially adapted tripod on which they can be adjusted for different relative optical axis angles and separation. As an experiment to investigate the extent of the stereo effect the cameras were connected to the red gun and the blue gun of a color television monitor and a pair of viewing glasses were made with red and blue lenses. The stereo effect was quite striking.

The monitor has been specified, ordered, and received. It is a Conrac model CQF14/R with a 525 line field and a 60 field per second scanning rate. The raster size has been adjusted so that it covers an area 6 inches by 8 inches. This is the size of the lenticular screen which will be mounted in the special cathode ray tube to be used in the monitor.

The specifications for the lenticular screen and the special cathode ray tube have been written and quotes requested. No bids have been received yet, but they should be received soon.

The block diagram of the BLAST system is shown in Figure 1. The 5.04MHz chopping generator has been designed and built and is shown in Figure 2. The diodes connected to collectors of the transistors become reverse biased when their respective transistors are turned off providing rise time of 5 nanoseconds. The fall time of the collector is also close to 5 nanoseconds.

The "divide by 153" circuit has been designed and is being fabricated. The circuit is shown in Figure 3. This circuit is used so that the television cameras can be locked to the video chopper and mixer with a minimum of lost information. If a "nice" number, like 160, were used, the horizontal scan would have to overscan slightly and this would result in a loss of information at the end of each horizontal scanning line. The division accomplished by this circuit can be easily changed over the range 1 to 256 by simply changing the choice of the inputs to the 8 input NAND gate.

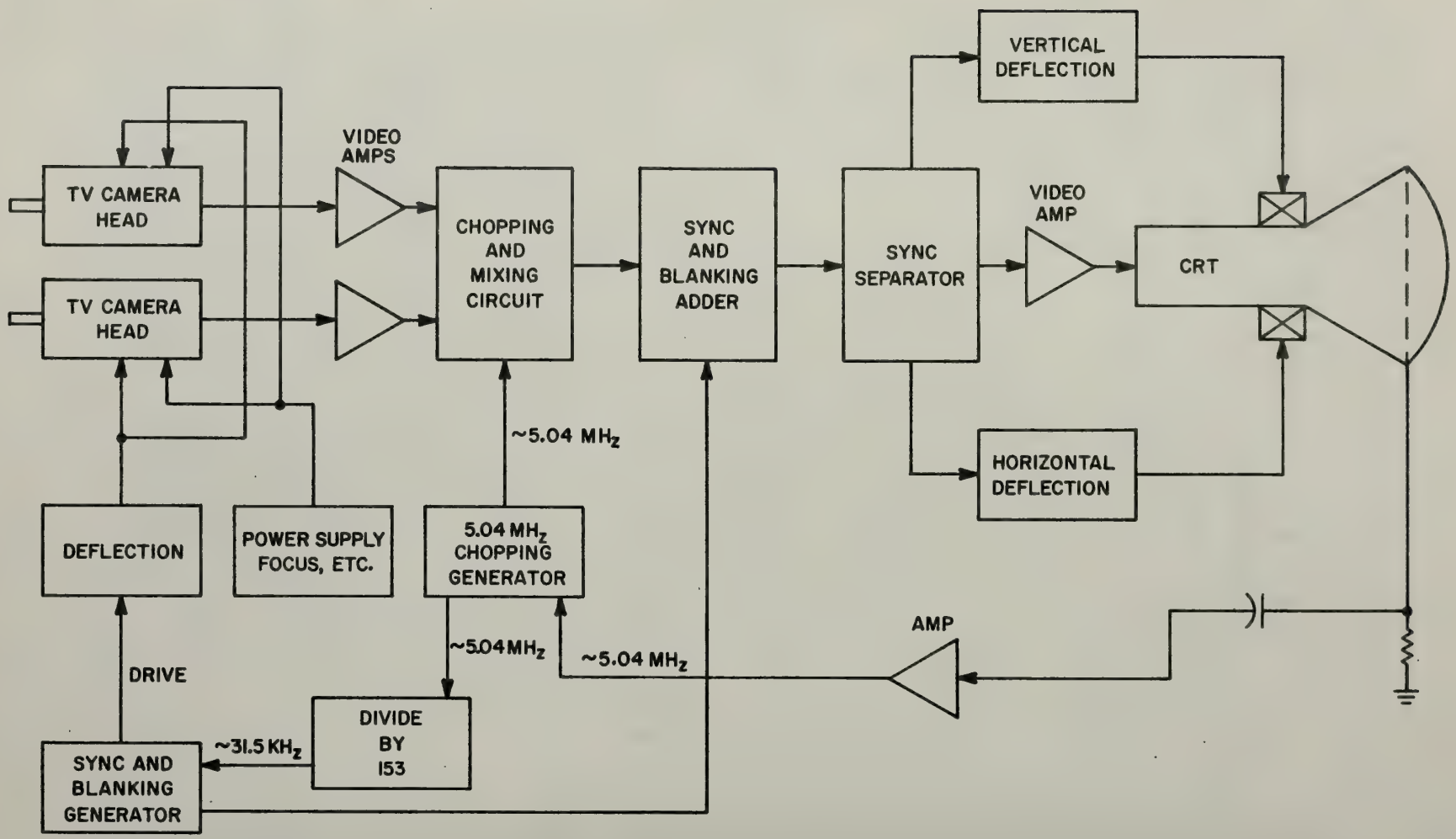


Figure 1. Block Diagram of BLAST System

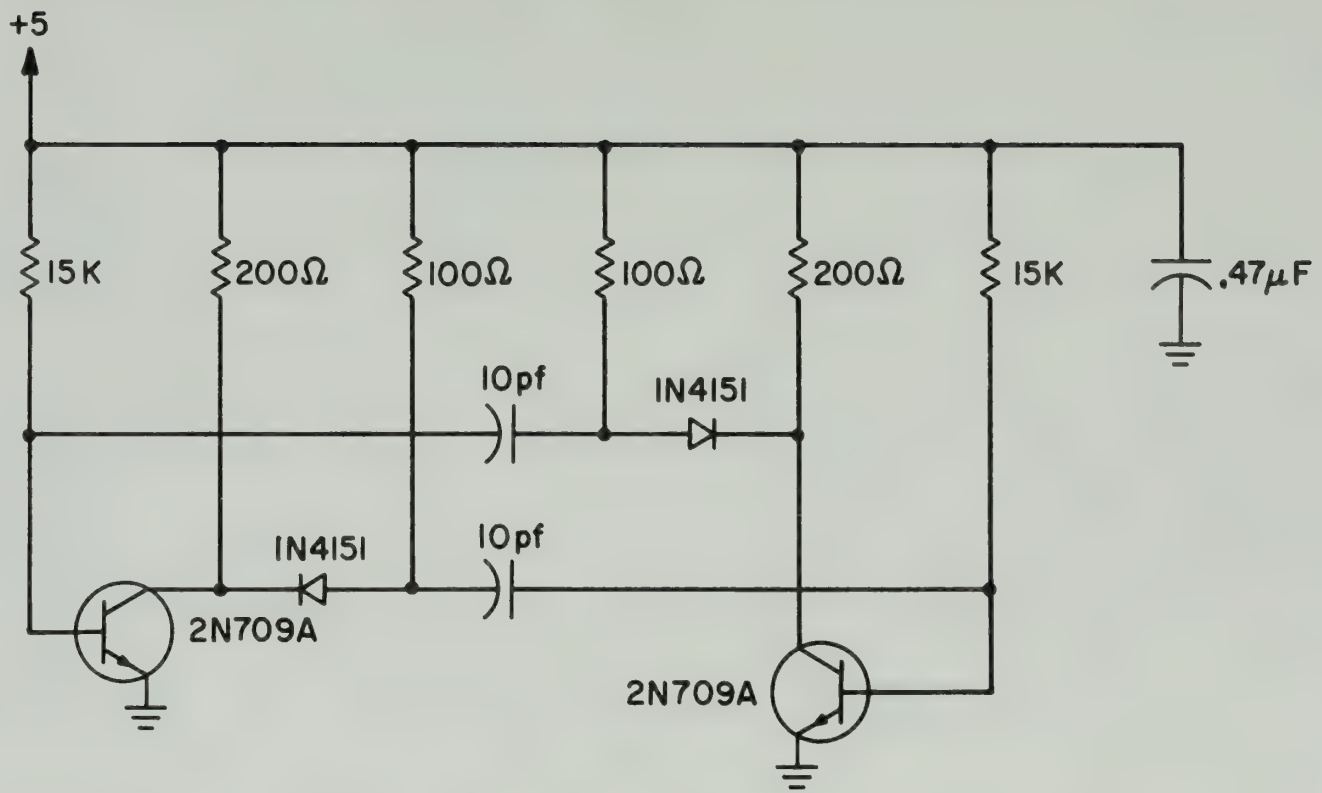


Figure 2. 5.04MHz Astable Multivibrator

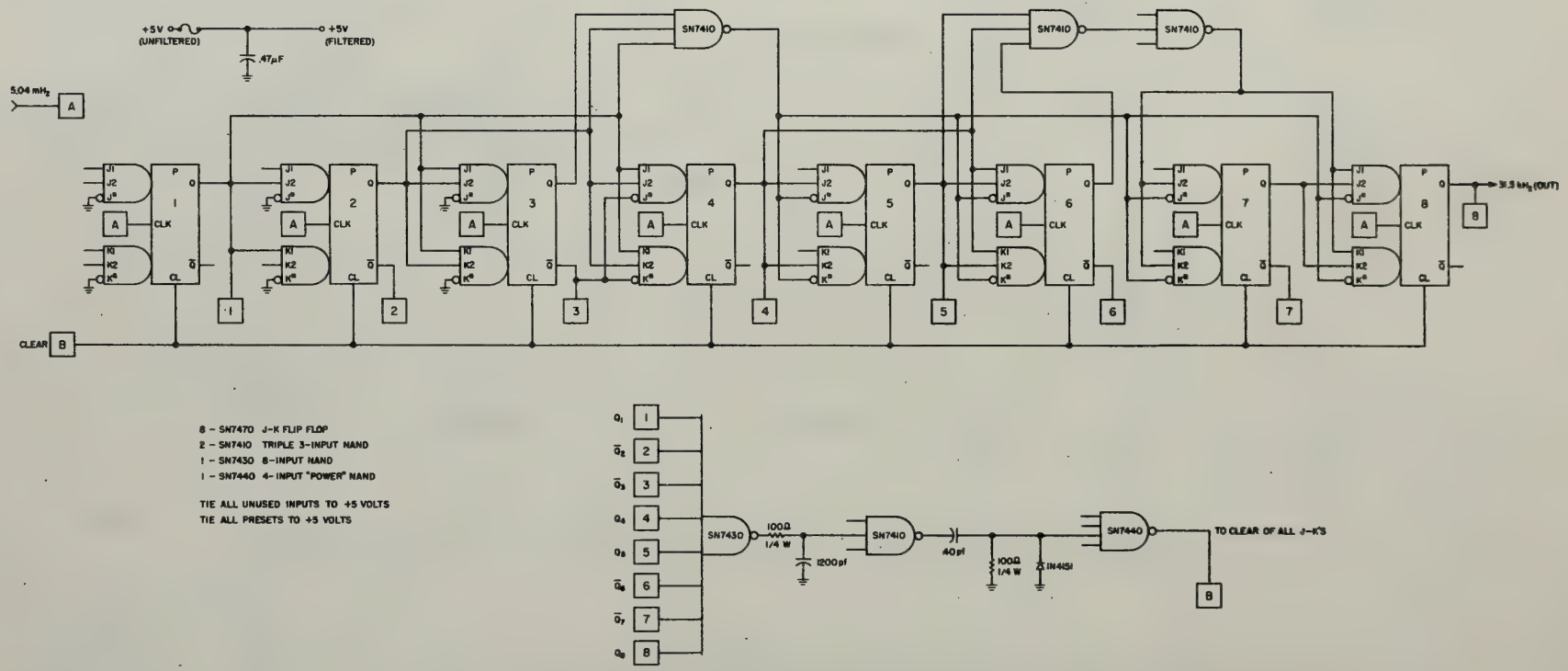


Figure 3. Divide by 153 Circuit

The linear integrated circuit, MC1545, has been tested for use as the video chopping and mixing circuit and has been found to be marginally satisfactory. An attempt is being made to develop a discrete component circuit which is better. Some success has been achieved in this area and work is continuing.

L. Wallman

2.7 STEREOMATRIX Project No. 30

As described previously, STEREOMATRIX is a display system which presents computer-generated three dimensional wire figures by means of two polarized laser beams. The stereo coordinate Transformer operates on each point of the figure to obtain both a right and left eye view. These views are displayed on a screen. The Coefficient Generator enables the observer to rotate, translate or scale the displayed figure. The observer's position is monitored so that the displayed figure can be modified in such a way that he always sees the correct view for his position. The Observer Position Detector and the Coefficient Generator are inputs to the stereo coordinate Transformer. The Transformer outputs control the laser Display.

2.7.1 Observer Position Detector

Ultrasound is being considered as a means of detecting the position of the observer. An ultrasonic transducer is currently being tested. It is operated at 30kHz and at this frequency has an impedance of about 115 ohms. Because of this relatively high impedance, it is difficult to drive it at a reasonable output level. A better transducer is being procured. A better microphone is also being obtained, as the one presently being used has poor sensitivity at 30kHz.

C. Pirnat

2.7.2 Coefficient Generator

The Coefficient Generator supplies the stereo-coordinate Transformer with the nine rotational coefficients, t_{ij}, and the three translation coefficients, t_{jk}, (where i = 1, 2,3,4; j = 1, 2,3,4, and k = 4). All computations are done digitally and converted into analog form before being supplied to the Transformer. The theory of operation and logic design of the generator have already been explained. A block diagram of the generator is shown in Figure 1 to illustrate the overall system with better detail. The rotational angle is controlled by a gate and is indicated on a digital readout device. Figure 2 is the diagram of the rotation and translation control. Rotation about the x, y or z axis is controlled as shown in Figure 3. The sequential control is achieved by using three individual binary counters and a gating system.

Some of the major subsystems which are commercially available have been evaluated: a) a 4K x 10 bit core memory, b) a 10 bit D/A converter with 0.1% accuracy and c) IC logic. Because the updating period is 1.3×10^4 μS minimum, there is more time for computation than is required. Thus, the core memory can be slow. A 3μS cycle time random access memory is the most common one in this category. One of the functions of this memory is to store some test patterns for testing purposes in addition to table look up for sine and cosine functions. The D/A converter is used to convert the computed 10 bit coefficients into analog voltages, the accuracy requirement being 0.1%. There are twelve coefficients, thus twelve D/A converters are required. The multiplication is achieved by using a shift and add scheme. All of the integrated circuit packages are to be TTL. Because of the latest price reduction, TTL is not much more expensive than RTL. The clock rate will be determined after the memory is chosen. Since the computer is a 10 bit system, each of the logic symbols in the figure represents 10 elements.

The memory, the D/A converters and the logic elements will be ordered in the near future. The detailed design of the control, the multiplier and the timing circuits will be attacked next. Also, the power supply requirements and the interfacing of the various sub-

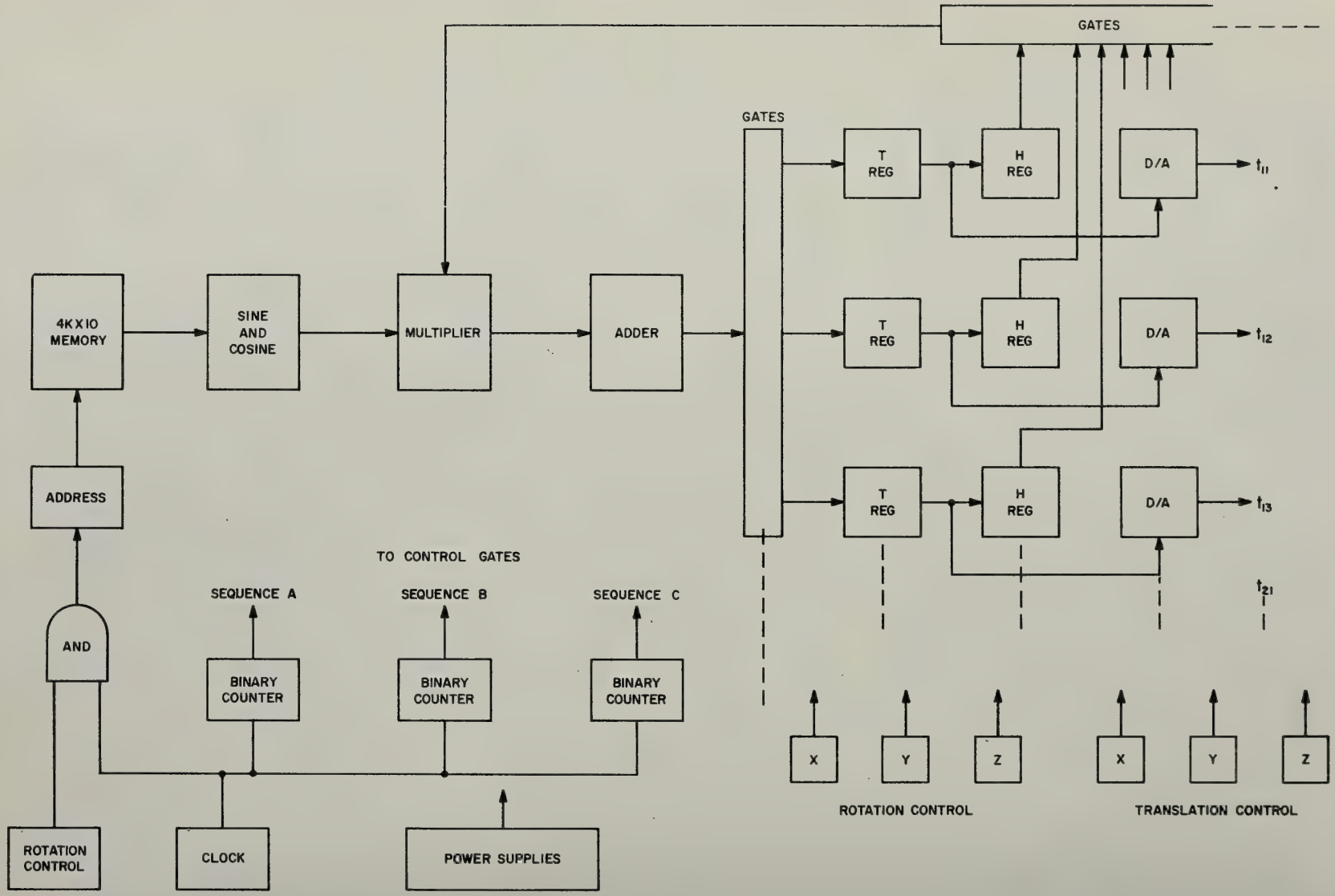


Figure 1. Block Diagram of Stereomatrix Coefficient Generator

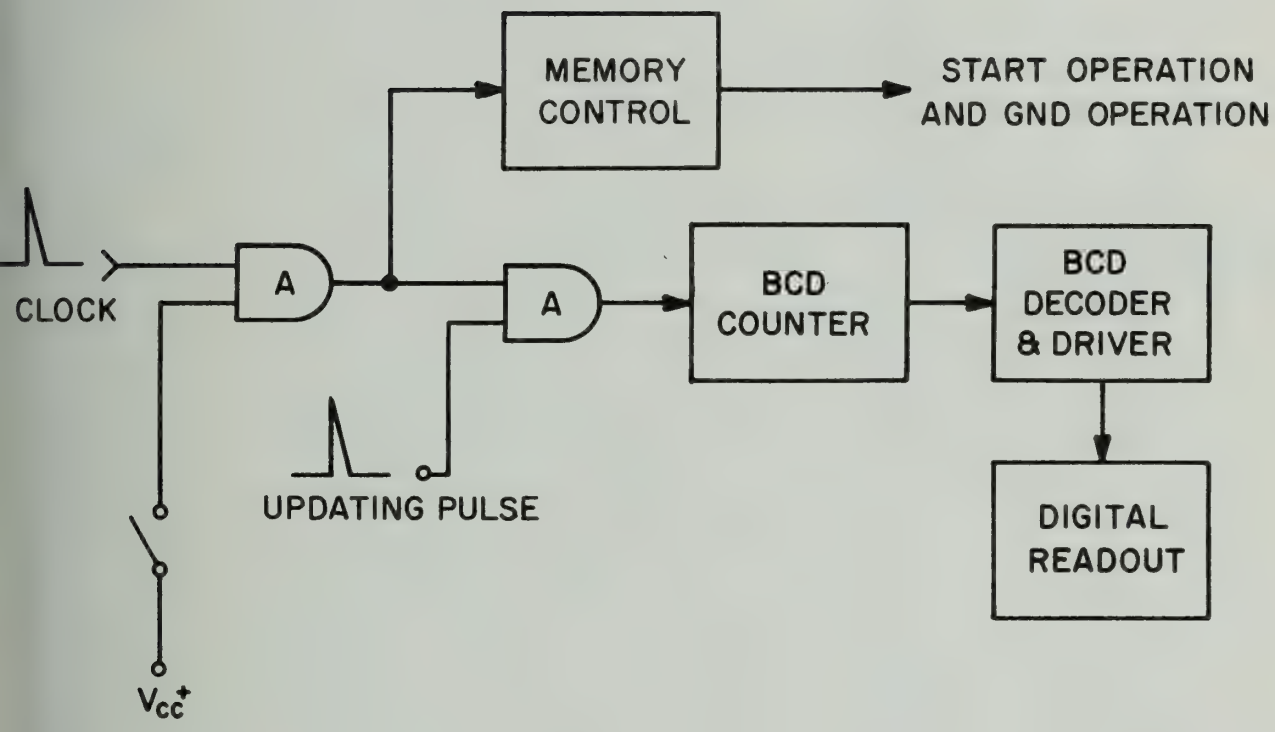


Figure 2. Rotational Angle Control

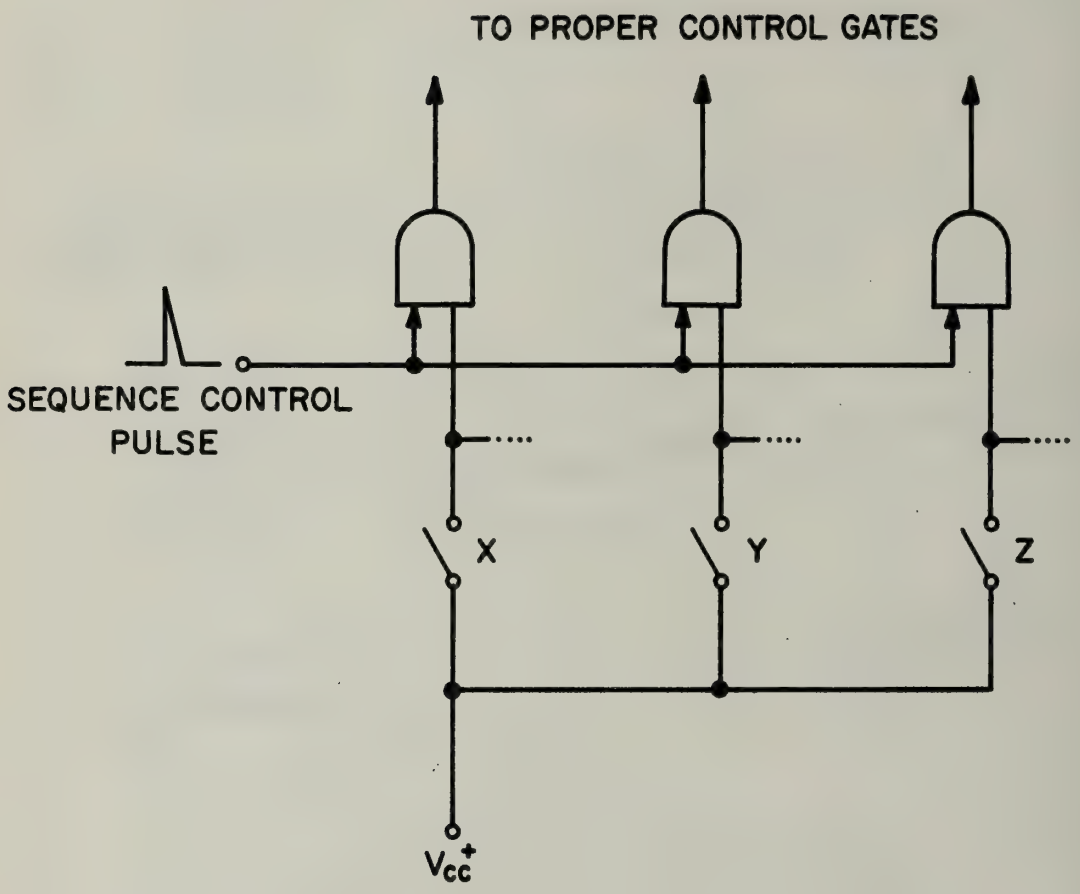


Figure 3. Rotation or Translation Control

systems will be given consideration. Some decisions have been made on the physical layout of STEREOMATRIX.

R. Cheng

2.7.3 STEREOMATRIX Transformer

The Transformer interacts with the input interface, the Coefficient Generator, the Observer Position Detector and the laser Display system.

The Observer Position Detector supplies to the Transformer the coordinates which describe the location of the observer relative to the display. The picture coordinates (points to be displayed) are supplied to the Transformer from disc storage. The Transformer, utilizing these inputs plus the coefficients from the Coefficient Generator, performs the transforming, scaling, windowing and perspective operations and provides stereo-pair deflection and blanking signals to the Display.

A block diagram of the Transformer showing the various subunits is shown in Figure 4. Due to the slow recovery time of analog circuits, the windowing is performed before the perspective generation and after the scaling to avoid saturation. Thus, points which are within the window space are sent to the perspective generator and those outside are rejected. Hardware will be designed to perform this function. Figure 5 shows how the windowing unit performs the required function.

The Transformer multiplies the coefficients obtained from the Coefficient Generator and sums them to form the new coordinates (x_t, y_t, z_t). A block diagram of the coordinate transformer together with the scaling unit is shown in Figure 6. Modifications to the stereo-pair signals are made depending on the position of the observer (x_o', y_o', z_o').

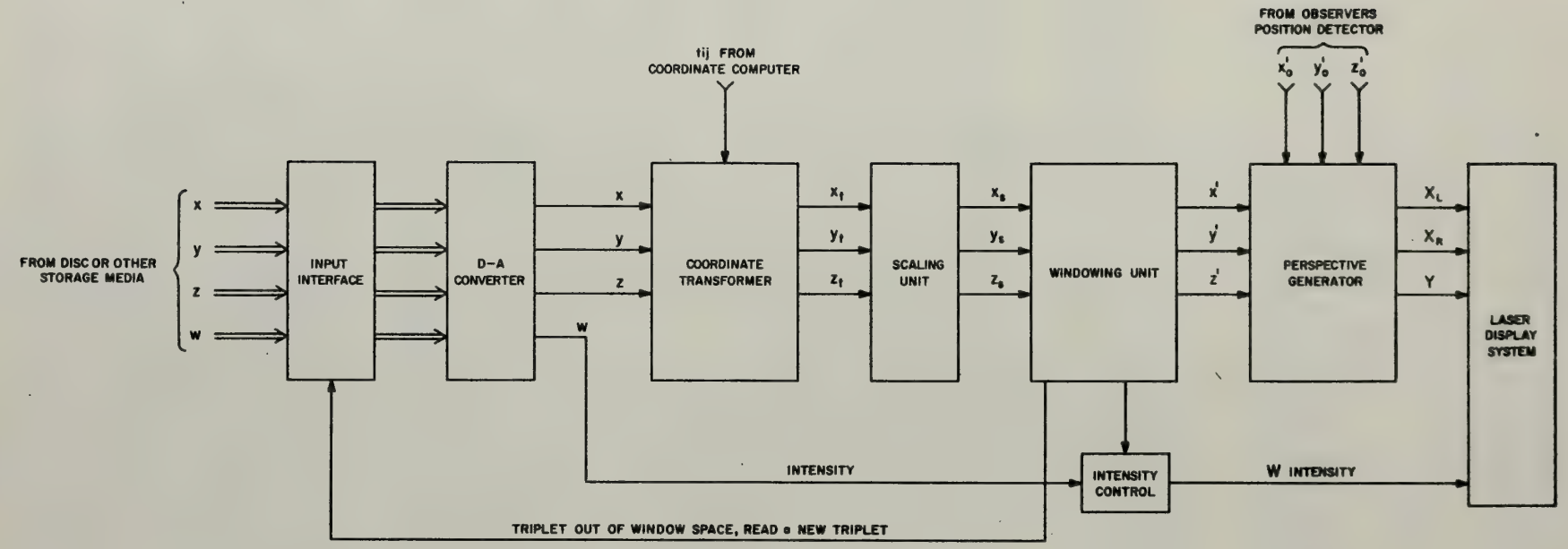


Figure 4. Block Diagram of the Stereomatrix Transformer

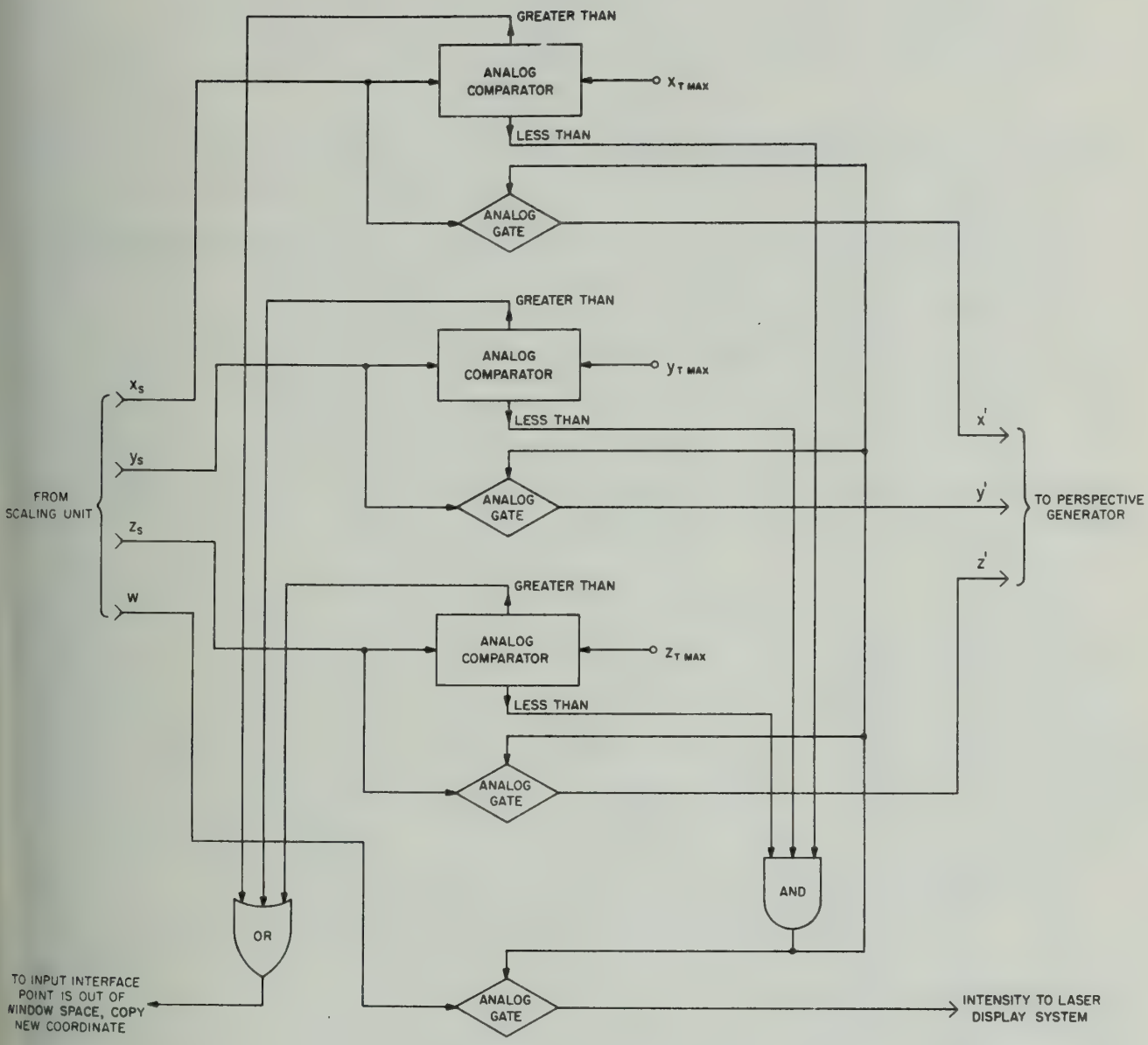
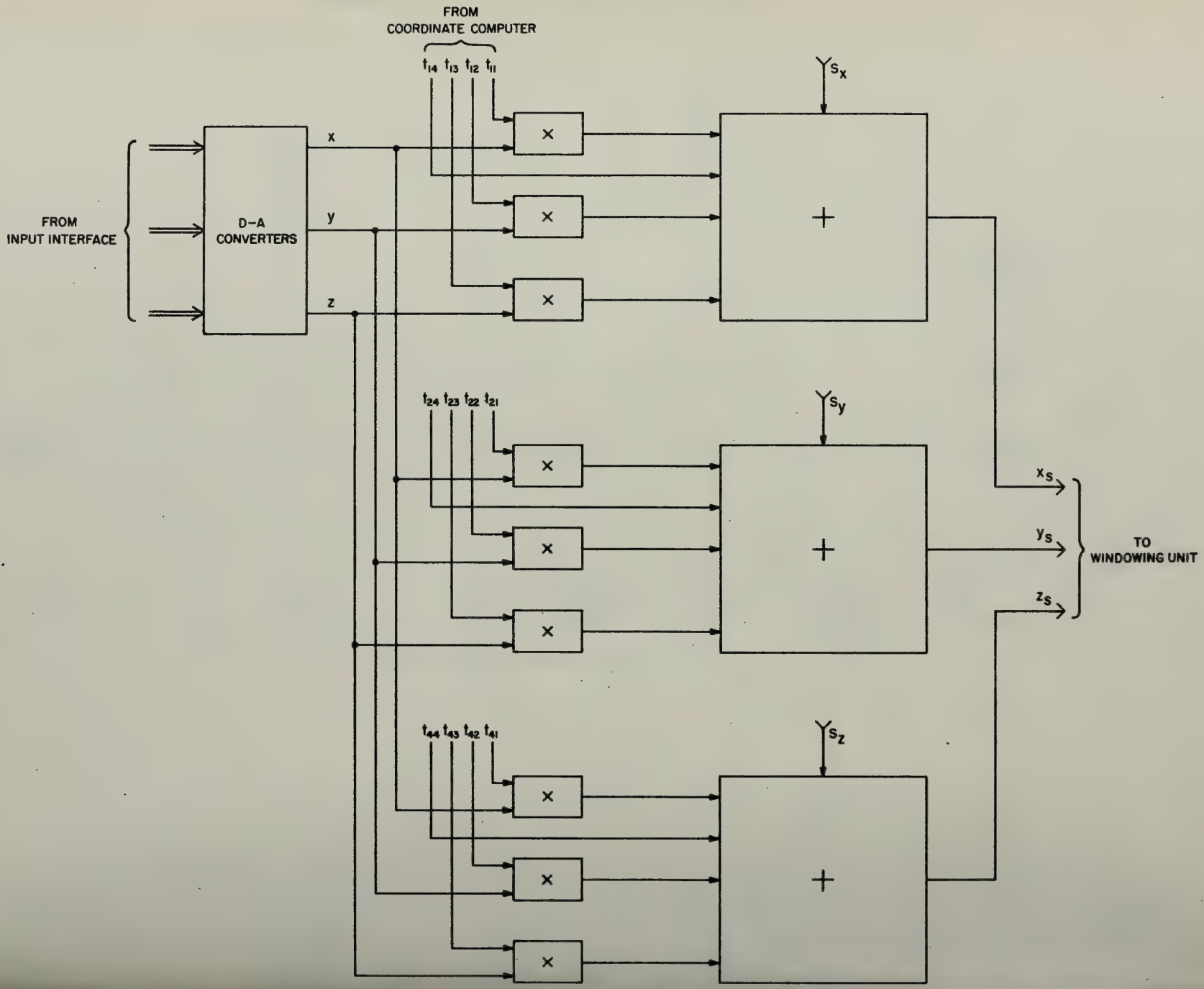


Figure 5. Windowing Unit


FROM
COORDINATE COMPUTER
t_{14} t_{13} t_{12} t_{11}
S_x
FROM
INPUT INTERFACE
D-A
CONVERTERS
x
y
z
t_{24} t_{23} t_{22} t_{21}
S_y
t_{44} t_{43} t_{42} t_{41}
S_z
x_s
y_s
z_s
TO
WINDOWING UNIT

Some changes have been made in the bock diagram of the perspective generator as given in previous reports. Only one divider is needed rather than the three dividers in the previous diagram. A complete revised block diagram of the perspective generator is given in Figure 7.

Analog multipliers and operational amplifiers have been ordered for evaluation. An Intronics multiplier (M502) was tested and worked satisfactorily up to 200 kHz, while our system requires a speed of 2-3 MHz. Motorola's MC1595 multiplier was ordered and is being tested. In addition, a Hybrid-Systems multiplier (M105) has been ordered for evaluation. It is expected that either the Motorola MC1595 or the Hybrid-Systems M105 will serve the purpose. Thus, it will soon be possible to order some of those components. Consideration is also being given to mechanical parts and power supplies.

Shiv Verma

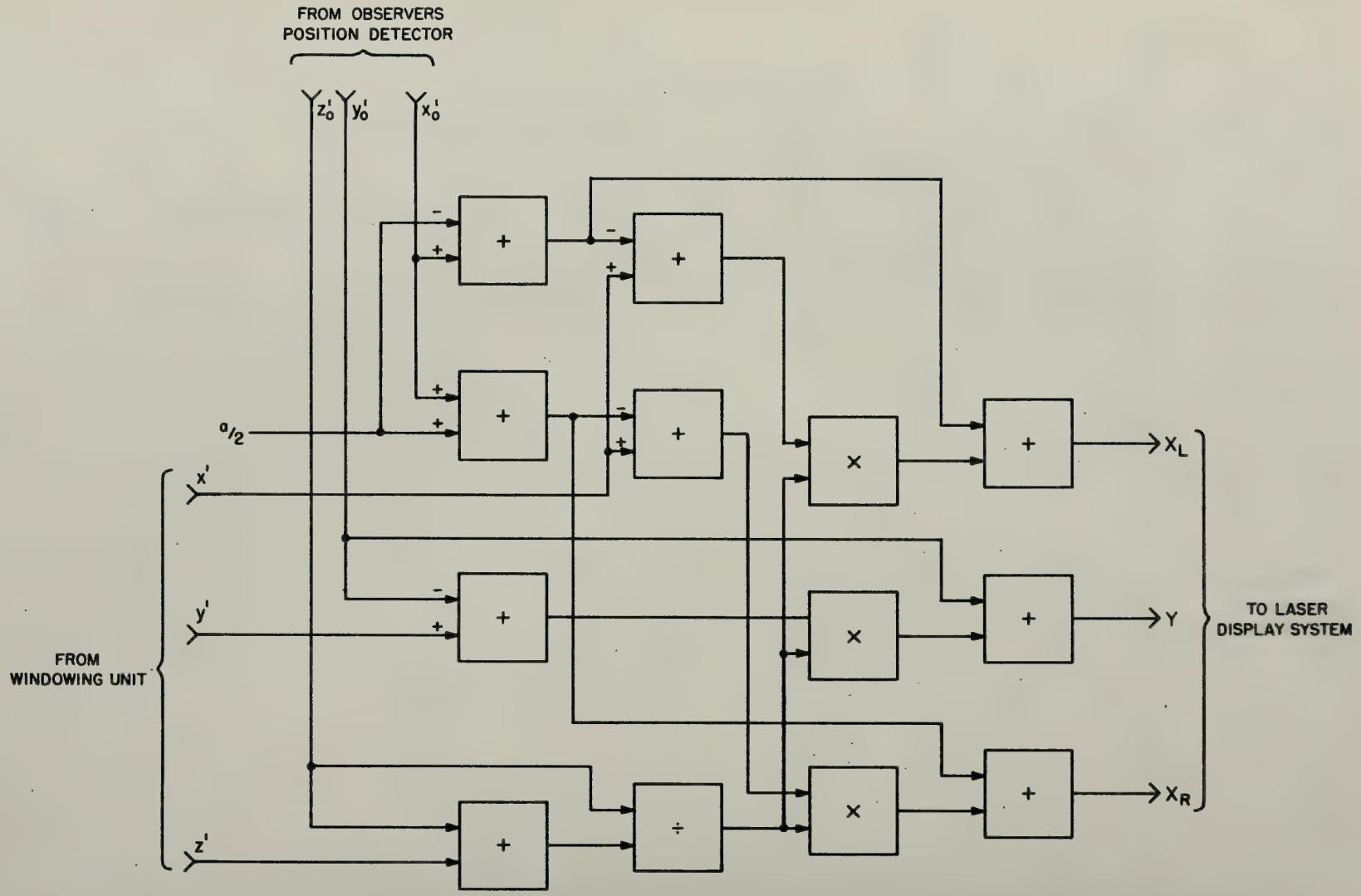


Figure 7. The Perspective Generator

2.7.4 The Display

The major problem in the display was the selection of two polarized light sources of sufficient brightness. Specifying an image brightness comparable to televison and estimating optical losses at fifty per cent, it was decided to use the one-watt 514.5nm line from an Argon-Ion laser. This one-watt line will be intensity modulated and then divided into two beams before being deflected individually to trace the right and left images. Figure 8 is a diagram of the display system.

The problem of deflecting a light beam at megahertz rates is acute. Ultrasonics seems to offer the most promise since random access is desired. However, the light lost in ultrasonic deflection is fairly high and this may be a problem. Nonetheless, specifications for the ultrasonic deflectors are being written.

The viewing screen also presents a problem. Rear projection is desired, but maintaining the distinct polarizations may be difficult. Experiments have shown that the ordinary rear projection screens are inadequate. Aluminized screens may be satisfactory but would probably introduce a large light loss. Some sort of lens-like screen may be a possibility.

S. Whiteside

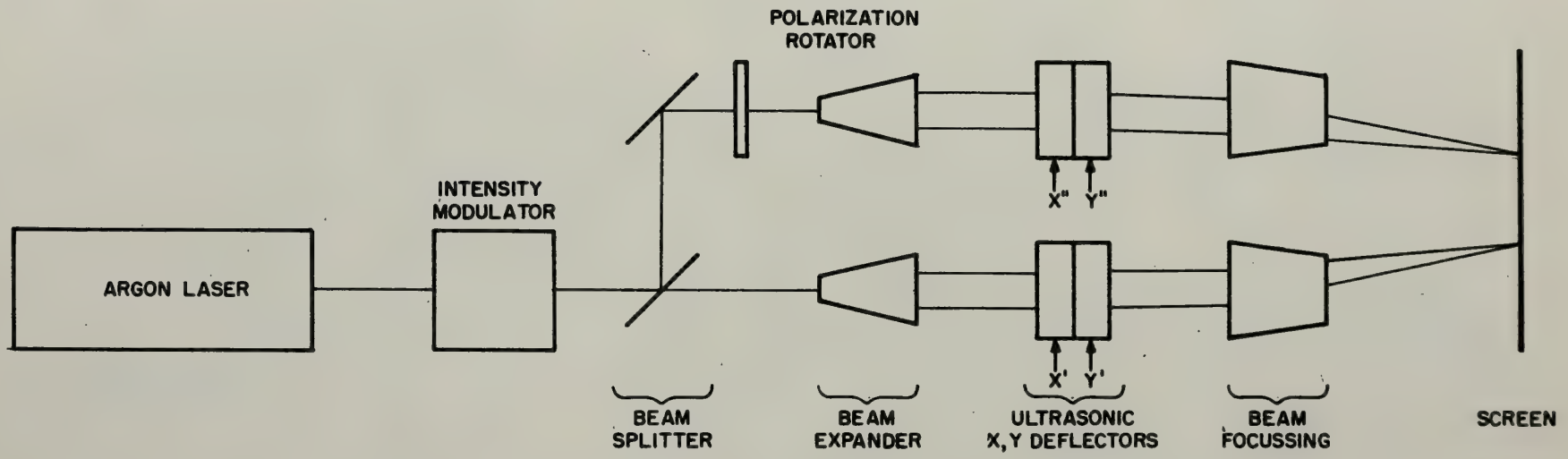


Figure 8. Stereomatrix Display System

Form AEC–427
(6/68)
AECM 3201

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3. COMPUTER SYSTEMS RESEARCH

This work was supported in part by the Department of Computer Science, University of Illinois at Urbana-Champaign, Urbana, Illinois, and in part by the U. S. Atomic Energy Commission under Grant U. S. AEC AT(11-1)1469, Part A.

Reports Written

1. Gear, C. W. An Interactive Graphic Modeling System, Department of Computer Science Report No. 318, University of Illinois, Urbana, Illinois 61801.

2. Michel, M. J. User Programming Specifications for the PDP8/360 Communications System, Department of Computer Science Report No. 317, University of Illinois, Urbana, Illinois 61801.

3. Rettig, J. A Test Mode Approach to Fault Detection in Sequential Circuits, Department of Computer Science Report No. 326, University of Illinois, Urbana, Illinois, and submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer Science.

4. Vohra, R. Study of Stability for Non-Linear Ordinary Differential Equations, Department of Computer Science Report No. 327, University of Illinois, Urbana, Illinois, and submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer Science.

5. Wilkins, S. Representations of Process Parallelisms, Department of Computer Science Report No. 328, University of Illinois, Urbana, Illinois, and submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer Science.

C. W. Gear, Principle Investigator

3.1 Ordinary Differential Equations

3.1.1 Automatic Differential Equation Solver (C. Ellis, K. Ratliff)

ODESSY Update: The system macros used by the Supervisor program to handle input-output operations have been added to the ODESSY deck.

In addition a final call to the system routine SYSERR has been eliminated since its inclusion in the program for use on other systems would involve too large a segment of the University of Illinois system software. It has been replaced by final use of the FORTEXIT and LEAVE macros.

University of Illinois CalComp routines called by the integration program have been replaced in the deck by dummy subroutines, so that users on other systems can insert the appropriate subroutines if they wish to use the CalComp option.

Some testing has been done on the integration method used in the ODESSY program. The step size used for the integration is normally bounded by the size of the print interval. Also doubling of the step size when tests indicate this is advisable is inhibited by the fact that the end of a number of steps of integration must be a print point. Indications thusfar are that removal of these restrictions leads to unrealistically rapid step doubling. The estimates for the amount of doubling to be allowed may have to be revised.

Also, the possibility of changing the order of the method to two orders below the current order will be investigated, rather than changing order one level at a time.

In the investigation of inversion techniques for sparse matrices, the present program assumes that information about the elements, rows, and columns in the matrix to be inverted is coded and stored in an array. This information is used to choose the order of pivot elements for Gauss elimination in such a way that a minimum number of nonzero elements are introduced by the inversion process.

3.2 Graphics

During this and the previous contract periods, the decision to implement a system utilizing the results of several areas of current research was gradually reached. The system will bring together work being done in differential equations, DEC 338 graphics, 360/338 monitor systems, and the DPU and disk design projects, as well as open research into the currently unexplored regions of symbolic manipulation and information retrieval. As currently envisioned, this system will be a graphical, remote access simulation system in a multi-terminal environment and will be capable of handling a large class of problems in the manner described by C. W. Gear in File #317. The overall description of the system is presented in a paper available from M. J. Michel.

The progress of system and utility software is discussed in this section; work on the analysis software is found in section 3.1; and DPU and disk development is described in section 3.4.

3.2.1 Disk Operating System (H. Levin)

Work this quarter has proceded in two main directions--hardware checkout software and applications software.

3.2.1.1 Checkout

Routines written uncovered several timing and signal errors which were subsequently corrected. However, one of the locations in SKIP-on-done/JMP.-1 loops used after initiating disk transfers is occasionally set to zero, thus causing the program to bomb out. This appears to occur randomly and either the SKIP or JMP is wiped out. Unfortunately, this has proven an elusive bug and has not been corrected yet.

The disk has been shown to be highly temperature sensitive. If the operating environment is maintained at 76°, no errors are found by the disk test routines and only the bomb out problem, mentioned above, causes trouble.

3.2.1.2 Applications

The filing system described last quarter will be used as part of the utility operating system for program updating and file maintainance. Another group of routines will be used for file manipulation by the proposed simulation system. These routines effectively divide the disk into three areas, one for program modules, one for bank swapping, and one for library blocks. All data blocks in the three regions are accessible by exact disk location (track, sector, block) or by sequential block number.

For the simulation system, a minimum number of programs will be kept on one track in predefined locations. This enables rapid access to routines used for extended interrupt service such as the drawing programs, text editor, etc. The bank swapping area (8 tracks) can store entire PDP8 core bank images on each three alternating sectors of a track (e.g. on 0, 2, 4; 1, 3, 5; 6, 8, 10; 7, 9, 11; etc.). Hence, an entire bank can be read or written in only one disk rotation. The library section (15 tracks) is considered to be 1800 blocks (ten 128 word blocks per sector) of directly accessible data. Since only sector size blocks can be read or written, this requires blocking and unblocking records, a time consuming process unless a permanent sector size buffer is used. To alleviate this, a suggestion has been made to add a selective read facility to the disk. This would cause only the specified blocks within a sector to be read into core. Elimination of blocking and fixed buffers would thus be accomplished for reading, which is the dominant operation in picture creation.

Decoders for both numbering schemes have been written, and a version of the bank swapping routine has been coded, but not fully debugged.

3.2.2 DEC 338 Software (C. Hyde, T.-Y. Lo)

Before leaving the project in May, Mr. Lo made several improvements to the new generalized drawing package. These included scaling of the completed element, addition of the element to a sub-picture menu, and the displaying of multiple lines of characters at points within an element. The work on this part of the project has been taken over by Mr. Chuck Hyde, and his subsequent activity is outlined below.

The implementation of the general purpose display package was interrupted briefly to permit an evaluation of the existing programs and to become familiar with the requirements of the proposed system.

After consideration of the environment in which the program will run, it was decided to redesign the drawing frame to permit a more efficient use of the display area. It was also decided to change the present method of constructing subpictures for a display file.

Work has been started on implementing several desirable features for testing the display package. A new interrupt handler is being written which closely simulates features of the final system. Such items as joystick information and two-level interrupt queuing are handled. The display program is being partially rewritten in order to make it serially re-usable and to change the internal representation of the data structure to facilitate the handling of subpictures obtained from a library of subpictures.

3.2.3 Graphics Monitor (M. Michel)

Due to the altered scope of the project, the current 360/338 monitor system (GRAFMON/UIMON8) being a single console, limited access package, has been "frozen" at its present state of development. The new monitor system (GASP/GLASP) will support multiple graphics or keyboard consoles attached to the 360 system via a variable number of

control devices, the major of these being the PDP8. Since the timesharing region of the /360 can look like a "device" to the monitor, all PLORTS terminals also have access to the system.

3.2.3.1 Graphics Attached Support Processor

The new monitor for the /360 part of the system (GASP) is a complete departure from GRAFMON rather than a revision. However, the macros previously written for users programs which provide translation and communication linkages will be changed more in name and spirit than in composition.

GASP consists of two sections. The first communicates with the /360 operator, attaches and terminates the second part of the system, and initiates recovery procedures in case of bomb out. The second schedules all interaction with individual consoles in the system, attaches and detaches subtasks for each console as desired, maintains a background job processor, routes requests and replys to and from the information retrieval component of the system (GIRLS), supports prompting (self-teaching and documentation) facilities, and performs accounting. (c.f. Figure 1).

Each "signed-on" console is represented by a LOGENTRY block (c.f. Figure 3). These blocks contain the console number, the device type, the "sign-on" identification, the subtask status, accounting information, prompting status, and requested I/O status. Whenever I/O is requested (by the monitor or by a subtask) the address of an I/O REQUEST block is placed in the appropriate field (as per device and read or write) of the LOGENTRY for the associated console. GASP is responsible for directing all I/O requests to the various device routines, formatting the data, adding control information depending on the device, checking for successful completion of I/O events, etc. (c.f. Figures 2, and 4-8).

A user at a terminal communicates initially with a submonitor in GASP. This monitor first requires valid "sign-on" identification. Thereafter, the user can enter run commands into the background job processor, can enter requests to GIRLS, and can request a subtask to

be attached. This subtask can then communicate with the terminal or any other terminal or device in the system. Typical subtasks would be interface, analysis, and applications packages.*

As mentioned, user macros (for programs running as subtasks) have been altered somewhat, and one new one has been created. This additional macro is used at the beginning of a program to pass linkage information from GASP to the communication routines in the subtask. These routines can then pass information on request back to the I/O request scheduling section of GASP. (c.f. Figure 9 for a brief description of the new form of the macros.)

3.2.3.2 Graphics Locally Attached Support Processor

The monitor for the PDP8 part of the system (GLASP) must now be capable of handling multiple graphics consoles. This requires that scheduling, terminal status updating, interleved picture processing, etc., be performed.* Basically, GLASP will be a two level interrupt processor, buffering I/O onto the disk as necessary and bringing extended interrupt routines into core along with stored data, in a task switching mode of operation.

3.2.3.3 Other Items and Current Status

A learning character recognizer has been completed and is operational in two versions, one for light pen input and one for tablet input. It can be added to a program as a subroutine for rapid (and natural) command input.

The /360 end of the debugging facility was partially implemented during this quarter, but debugging and completion have been interrupted due to the hardware and software changes now in progress.

The combined PDP7/PDP8 360 assembler for PDP7 and PDP8 programs has been, unfortunately, pushed far down in the work priority list.

---

* As described in M. J. Michel's unpublished thesis, "A Graphical Remote Access Simulation System."

GLASP is in the planning stages, with interaction among the disk, DPU, and drawing systems of prime concern. Implementation can begin as soon as GASP is completed. GASP is 75% coded and should be completed soon. However, complete debugging of the package will not be possible until arrival of the 2701 and until certain interface facilities have been completed in PLORTS. On the other hand, debugging of the 2701 hardware requires the availability of both GASP and GLASP in at least skeletal form, so a degree of parallel effort in GLASP will be necessary.

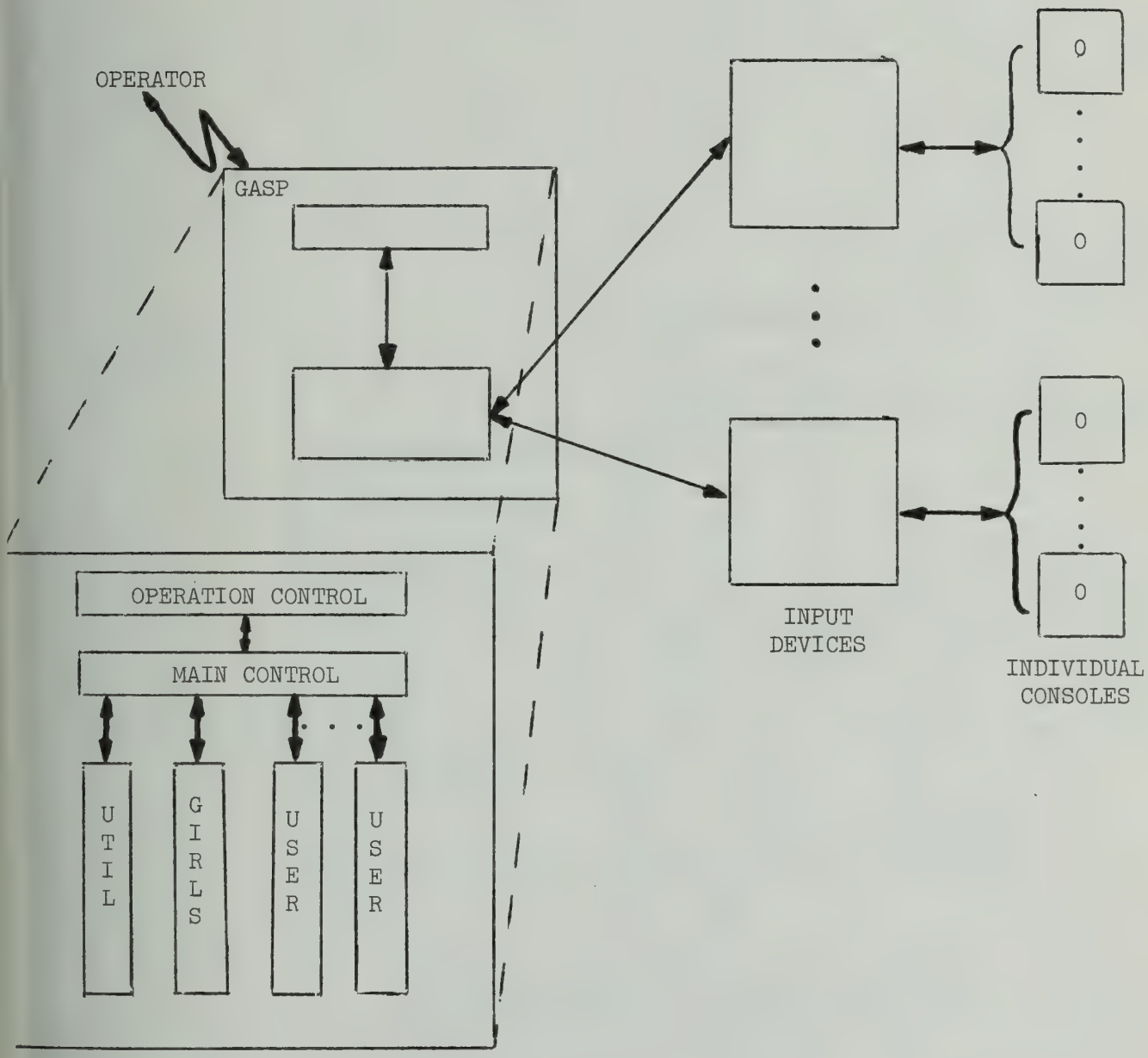


Figure 1

GASP Task-Subtask-Console Interrelationships

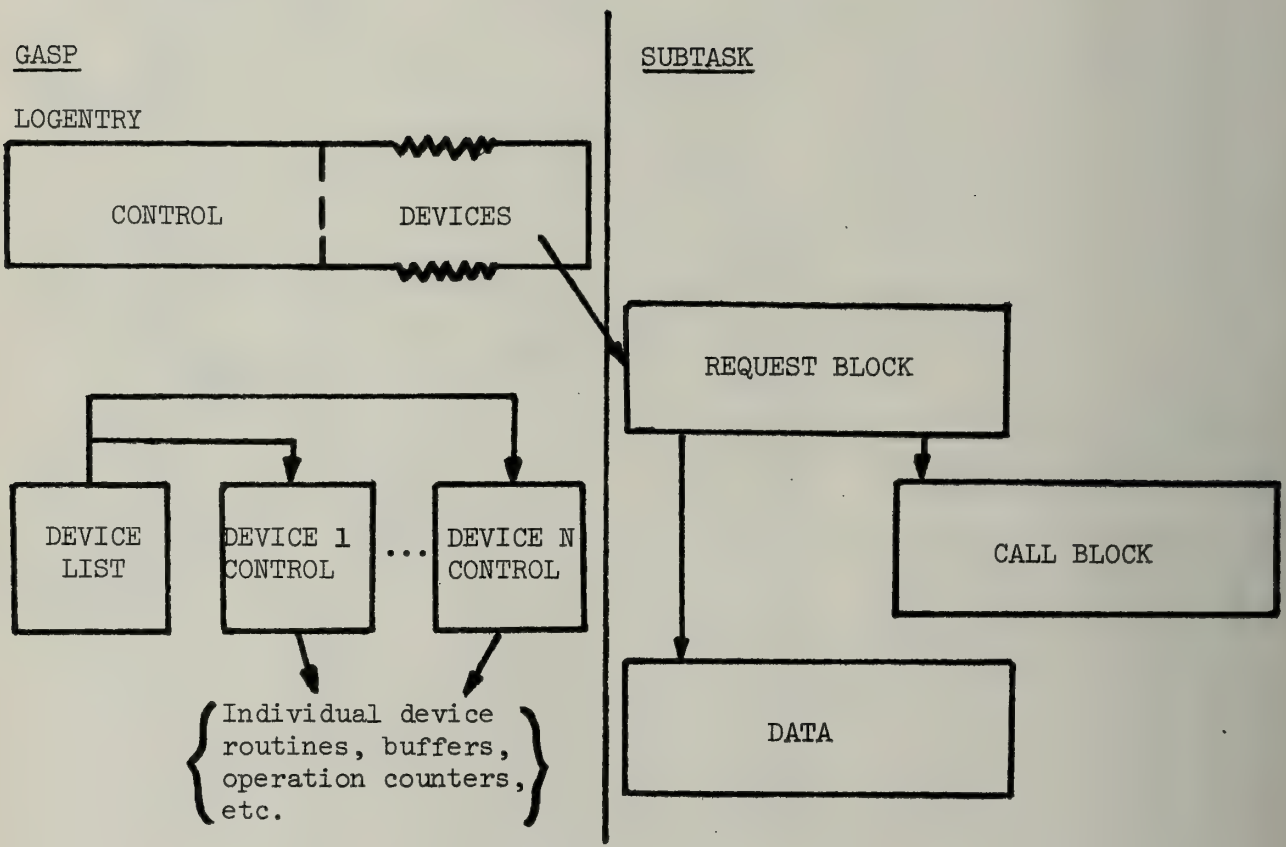


Figure 2

GASP Task-Subtask Control Block Structure

TERMID : Remote console real identification: 0-FC, FD=UTIL, FE=SYS, FF=entry unused

ØRIG : Console logon device source: PDP8 = 0, TS = 8,...(i.e. logon occurred at this device)

LØGFLAGS: Bit 7 = (0:Monitor mode, 1:subtask attached)

LØGID : 21 byte field with TS type logon info: XXXX,NAME

TIMEØN : Time at logon

TIMEØFF : Time at logout

TØTTIME : Total subtask-active time accumulated while logged on

MSGSEQ : Byte 0 is messages remaining index, Bytes 1-3 is request block list address of messages

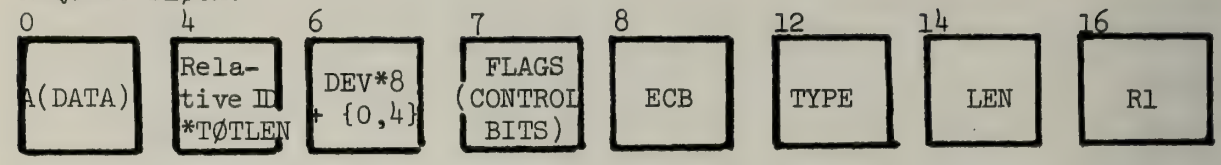
DEVnR : Device op word (Read): top byte flags (bit 0 = OP Pending, bit 2 = priority pending), bytes 1-3 point to request block

DEVnW : Device op word (Write): same as DEVnR, plus bit 1 = check pending

Figure 3

GASP Log Entry Block

REQUEST BLØCK:



DATADDR: A(Data bytes ready to go)

RELID : 0,TØTLEN,TØTLEN*2,etc. (relative position of log entry)

ØP : 8R=0,8W=0+4,TSR=8,TSW=8+4...

RQFLAGS: Right 6 bits of control byte (all devices)

SUB : SUBTASK ECB for op complete

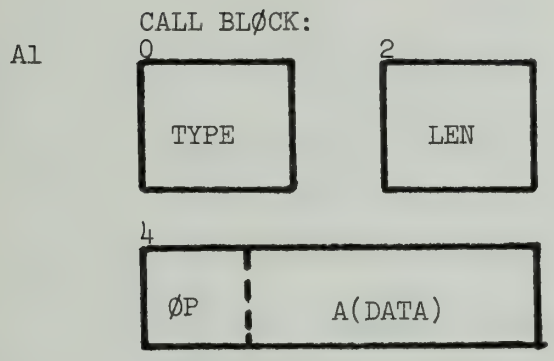
RQTYPE : Right 12 bits put into type bytes for PDP8 write

RQLEN : Data length in bytes, TS $\leq$ 125, P8 $\leq$ 250, 0 = NØ DATA

RQR1 : A(CALL BLOCK)

Figure 4

Subtask Request Block



TYPE : Right 12 bits put in request block for Write

Right 12 bits are result type bits on PDP8 Read, junk on TS read

LEN : Bytes requested for Read or Write

After read, is difference: record count minus request count (hence -N short record, +N long record)

DATA ADDR: Addr of read or write area put into request block

Byte 0 = operation flags

Figure 5

Subtask Call Block

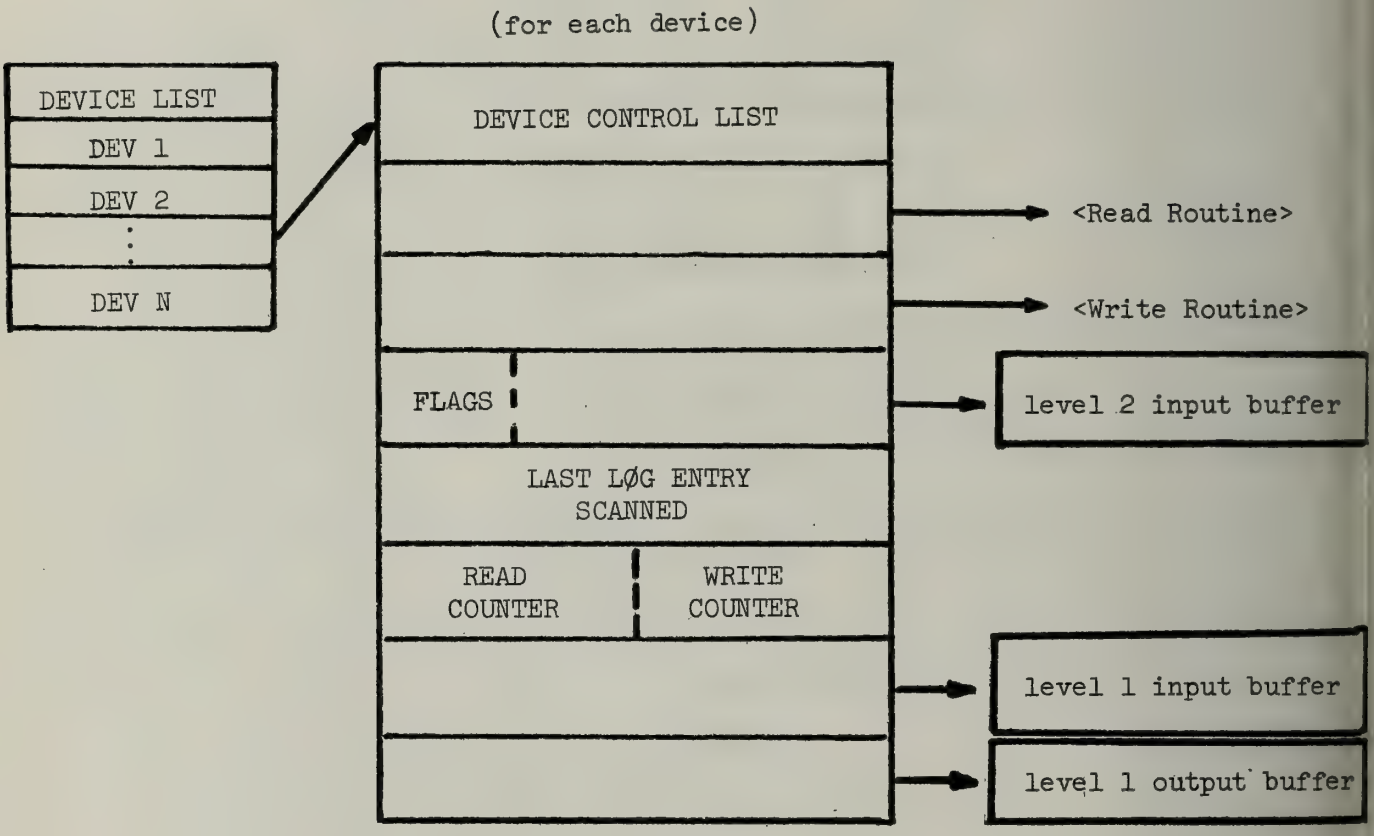
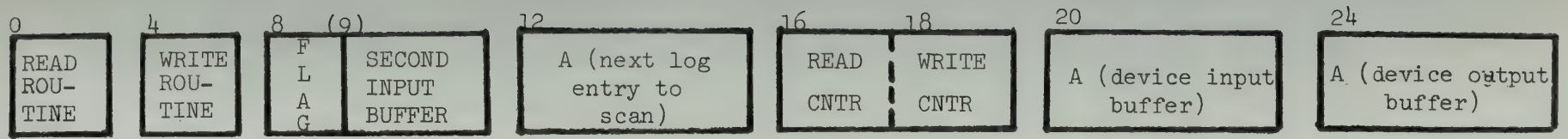


Figure 6

GASP Device Control Block Structure



RDØP : A (device read routine)

WTØP : A (device write routine)
FLAGS:
BIT0 - WBUSY - write in progress
BIT1 - PRIØR - priority op pending
BIT2 - STARTIN - read attn set
BIT3 - WPEND - write op pending
BIT4 - INRECVD - input ready in second input buffer
BIT5 - DFULL - input ready in device input buffer (i.e. full)
BIT6 - WFULL - write output buffer ready (full)
BIT7 - RBUSY - read in progress

L2BUFF : A (second level input line buffer) is filled from real input buffer (level 1)

NXTSCANE: A (last log entry scanned)

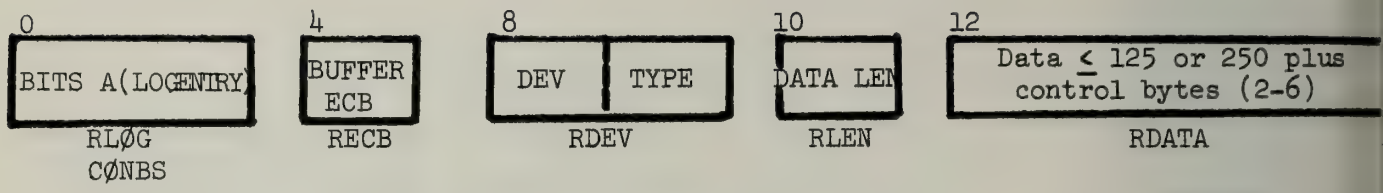
CNTRS : $\frac{1}{2}$ word read op/write op events pending counters; used to send main flag bits

DEVNBUFF: A (main (level 1) device input buffer) real I/O done at this location

DEVNBUFØ: A (main (level 1) device output buffer) real I/O done at this location

Figure 7

GASP Device Control List Entry Detail



RLØG : A (logentry) corresponding to this data line

CØNBS: Right 6 bits for (from) control byte of data line

RECB : ECB used variously for input or output depending on device

RDEV : Top 4 bits filled in to specify device or I/O origin (0 = PDP8, TS = 1, etc.)

Right 12 bits for (from) type field of PDP8 I/O line or zero

RLEN : Byte length of data in data field

RDATA: Data field

Figure 8

GASP Buffer Detail

GRINIT - On initial entry to subtask, pass input parameters to main subtask interface, GRAPACK. (New macro)

GRREAD - Initiate device read operation; specify particular device. Form call block. (Extension of PDP7IN)

GRWRITE - Initiate device write operation; specify particular device. Form call block. (Extension of PDP7OUT)

GRWAIT - Await completion of one read or write operation; condition code returned in register 15. (Extension of part of PDP7EXCP facilities)

GRTRAN - Perform an in-place data translation operation. (Extension of PDP7TR)

GRAPACK - Maintain linkages to I/O schedular and translation routines of GASP; contains request block, buffers, ECB's, etc., for all devices specified. (Extension of PDP7EXCP)

Figure 9

3.2.4 DRAWL--Graphics Display Language (J. Roman)

Work on the interactive version of GDL is continuing. It is now hoped to produce a package capable of handling keyboard as well as graphical consoles, depending upon the "sign-on" parameters specified by the user. An initial version of a display file generator has been coded for use when graphics consoles are being used. Debugging of this routine is not yet complete.

An extended version of GDL is being considered that would enable it to be called from an executing program. GDL would then produce a data structure compatable with that of the general drawing program for the DEC 338, and this information would be transmitted to the PDP8 for display at the user's console. Hence, GDL would become an application drawing package, capable of interfacing arbitrary analysis programs with graphics consoles on an interactive basis. GDL's picture-subpicture capabilities along with access to the proposed Information Retrieval system would make this a particularly powerful, general facility.

3.2.5 FPL/II (S. Wilkins)

The simulation of flowcharts execution has been done thus far with (the flowchart on) card input in an 80 character transmission format that was used when FPL/I was written for the Illiac II. The new communication system between the PDP8 and S/360 via the PDP7 allows character transmission of up to 125 characters per line. The flowcharts in digital form as stored in a PDP8 memory bank will be transmitted now directly from the memory bank to the 360 at the maximum character rate without any preformatting. The program to create the flowchart table for 360 use has been modified for this change in transmission technique. A simple recognition routine has been incorporated into the program to break the transmitted records into the component descriptions of the flowchart, a task not needed before when each record had specifically designated fields. Macros have been provided which now translate the records from the PDP8 internal representation to the S/360 representation. The formatted records previously used were extremely inefficient to decode for the 360.

While altering the system for the new communication methods all coding is being re-evaluated and written more efficiently where possible. A well designed system is always carefully documented. In order to bring this system up to a high standard, all programs are being carefully commented and flowcharted. If the need should arise, all programs are also being modified to be used in an overlay structure.

Immediate plans for the flowchart system after completion of the work discussed above involve two major changes. 1) Presently, no flowchart is allowed to call another flowchart. This capability is a powerful tool and will be added as soon as possible. 2) Flowchart text is currently accepted only in postfix notation with blanks as required delimiters between components. The recognizer will be expanded to accept infix notation without blanks as delimiters.

3.3 PLORTS Timesharing System (A. Whaley, J. Christopher, P. Boekhoff)

The 360/50 system has been redefined; we are now running MVT and an upgraded version of ASP. The concomitant changes to the PLORTS system have been made, and we have been more or less on the air since early June. The current PLORTS system performs all intertask communication with ASP by means of the SVC proposed last quarter. PLORTS is now entirely independent of ASP with one minor exception (see below).

By way of eliminating several serious bugs and of providing greater operating efficiency, the filing system is being completely rewritten. The new version should be operational sometime in July, along with several new terminal commands.

Work has continued in earnest on Pass II; a number of statement routines have already been coded, and the crucial symbol table lookup routine is nearing completion.

3.3.1 Current System

The MFT OS on the 360/50 has been replaced by MVT, and ASP 2.2375 is now operational. The PLORTS and FILE DSP's now communicate with timesharing through IGC231, a homemade SVC routine. Linkage to this SVC is provided by ANIMI, an apparently unlimited macro whose format is as follows:

```
ANIMI  Function,Myid,Hisid,ECBAddr
```

where

Function is either SEND, RECV, XSEND, or XRECV. The latter two are cancel functions.

Myid is either a numeric value from 1 to 95 or one of the codes ASP0, ASP1,..., ASP31, TS0,..., TS31, GRX0,..., GRX31. The codes are purely mnemonic, for use by ASP, Timesharing and Graphics, and are translated by the macro into numeric values. The number is picked randomly by the user but must be unique among all users currently executing. It represents the ID by which the user wishes this call to be known.

Hisid has the same domain of values, and represents the ID by which the other caller for this same operation is known.

ECBAddr is the location in core of an area (fullword aligned) defined as follows:

Bytes 0-3	Event control block
4-5	SVC work area*
6-7	Length of data area
8-N	Data area

As an example of use, suppose that Task A wishes to transmit a message ($\leq$ 32767 bytes) to Task B (which may in fact be the same task; IGC231 may be used as a gilded MVC). He could then define

```
ECBA  DC  F'86'
      DC  A(12)
      DC  CL12'SIR, I  EXIST'
```

and issue the macro

```
ANIMI  SEND,13,69,ECBA
```

Upon return from the SVC, the first byte at ECBA will be set as follows:

X'40': Operation completed; a request for RECV with Myid=69 and Hisid=13 had already been issued. The other task has now been posted (his ECB contains X'40'). In addition, your ECB bytes 1-3 now contain what was in his ECB bytes 1-3 when he called the SVC, and vice versa.

---

* Must not be altered by the user!

X'20': This request has been accepted and enqueued pending the corresponding RECV request. When the RECV is issued, the data move and ECB swap will be executed and your task will be posted; you may now issue WAIT ECB=ECBA.

X'10': This request has been rejected. Another SEND,13,69 request is already in the queue.

Now suppose that Task B has not been heard from and that the request is placed in the request queue. It is to be hoped that at some later time Task B will issue the request

```
ANIMI  RECV,69,13,ECBB
```

where he has defined for example

```
ECBB  DC  F'99'
      DC  A(20)
      DC  XL20'0'
```

At this time the 12-byte message is moved to B's area (the SVC always uses the minimum of the two lengths), the ECB's will be swapped, X'40' will be inserted in ECBB, and Task A will be posted. The contents of the ECB's are now:

```
ECBA = X'60000063'
ECBB = X'40000056'
```

assuming that Task A left the X'20' bit in ECBA.

Any task may have a number of ANIMI requests outstanding; the only restriction is that there can be no more than 51 requests outstanding in the system at any one time. Timesharing, for example, has several requests outstanding at any time. When TS initializes itself, it cancels all of these before coming to life, just in case it crashed and is being restarted (if TS is not in core at the moment, IGC231 will not execute any requests from ASP to TS, but will queue them until TS is restarted and reissues its requests; that is, when a

task terminates, its requests are marked invalid by the SVC). A cancel request for a call which was not in the queue is harmless.

The swapping of ECB contents has turned out to be quite useful; for example, the FILE DSP sends an EOF indicator to timesharing by setting its ECB to X'00FFFFFF' and SENDing a zero length record.

The only connection between PLORTS and ASP other than the use of this SVC is as follows. When a terminal user issues a RUN (or RUNN) command, if ASP is dead or the PLORTS DSP is not in core, the issuing of an ANIMI SEND would effectively put that user in the wait state until the DSP is able to accept his job. Thus, before attempting to send data to ASP, timesharing checks one secret bit in core and rejects the command if this bit is off (the PLORTS DSP turns it on when it initializes and off when it is cancelled. If ASP is down, the search for the bit will indicate this).

The obscure but devastating bugs in the BLAM filing system have been deemed intolerable; BLAM is being rewritten to eliminate these. In particular, BLAM has been partially responsible for and unduly sensitive to system crashes. The disk pointers, both within files and in the free list, have become seriously bent. Further, the dump and restore programs--when they work at all--take on inordinate amounts of CPU time. For these reasons, BLAM has been largely redesigned and thoroughly recoded. Several new features, such as a command to read the last line of a file, have been incorporated into the new BLAM, and a COPY command and other improvements have been added to the system. This latter command is used for renumbering and concatenation of files; its use is of the form

```
OPEN  NEWFILE
COPY  OLD1,OLD2,OLD3
```

which appends the concatenation of the OLD files to the new one. The console monitor has been programmed to interpret all commands which it considers to be in poor taste as LOGOUT commands.

3.3.2 Pass II--General Comments

Definition of the general requirements for Pass II is becoming stabilized; current thinking is summarized here.

Main flow of control: the statement code (STC) of the first statement input from Pass I is checked to be sure it is a PROCEDURE statement. The PSTC (previous STC) byte is initialized. From then on, branches to the various statement routines are effected by using the STC as an index. The PSTC must be checked for certain statement types; e.g., DECLARE must be preceded by BEGIN, DECLARE, or PROCEDURE; ELSE by IF-THEN. At the end of input from Pass I, the block table is checked to see that all blocks are closed; all resolvable references must also be resolved at this time.

The STC is a halfword output by Pass I at the beginning of each statement. Pass II will, of course, not output this code to Pass III.

Labels: Pass I ignores labels on DECLARE statements; in all other cases, label data immediately follows the STC (a zero here indicates no labels). For all statements except BEGIN, DO, and PROCEDURE, the statement routine simply calls LABEL. This routine takes the following action for each label.

If the label is not subscripted, a symbol table entry for the given symbolic name is constructed, and its value is defined as the current controls of the Polish location counter. For a subscripted label, the symbol table for the current block is searched for a declaration of the given identifier as a label array. Assuming it is found, a dummy label constant is generated with the current counter as its value, and an assignment statement assigning the dummy to the specified element of the array is generated and added to the declaration file for the block.

A PROCEDURE statement must have one or more labels; these cannot be subscripted. The symbol table is searched for subroutine calls to the given procedure name(s). If the call is not found, it is defined at that point. A symbol table entry for the procedure name is made; its

value is the counter after the generated branch around the PROCEDURE. Then a new block is initialized, and the associated symbolic names are placed in a stack of names and level numbers.

Operators are halfword symbol table pointers preceded by one-byte ID flags marking them as operators. The symbol table entry for an operator points to the code to be executed by Pass III.

An identifier consists of an ID byte, a length byte giving the number of characters in the name, and the actual characters.

A constant consists of an ID byte, two bytes of symbol table information, a length byte, and the value of the constant.

An expression is a string of operators, identifiers, and constants. It includes an ID byte marking it as an expression, a length byte, and the string.

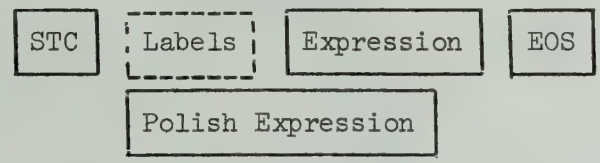
The current layout of the symbol table is as follows:

BYTE 0	BITS 0-2		0 constant
			1 variable
			2 * subscript
			3 dummy operand
			4 operator
			5 entry name
			6 procedure name
		3-4	0 bit string
			1 character string
			2 binary fixed
			3 binary float
		5	0 real
			1 complex
		6	0 scalar
			1 dimensioned
		7	1 label

BYTE 1	length of SYMTAB entry (e.g., 8 for identifier)	
BYTE 2	BIT 0	0 not allocated
		1 allocated
	1-2	0 automatic
		1 static
		2 controlled
	3	1 undefined label reference
	4-5	1 input file
		2 output file
	6	1 print file
	7	0 single precision
		1 double precision
BYTE 3	length of string (BIT/CHARACTER only)	
BYTES 4-5	pointer to data (in virtual memory)	
BYTES 6-11	characters of identifier (padded with blanks)	
6-N	value of constant	

3.3.3 Pass II Statement Routines

ASSIGNMENT



Action: After the initial call to LABEL, the entire statement is analyzed by a call to EXPR, the Pass II expression handler. This routine transforms the Pass I output into a string wherein all constants and identifiers are replaced by halfword symbol table pointers.

BEGIN

Input: STC | Labels | EOS

Output: none

Action: The labels are placed in the block stack; a new entry is made in the block table. The level number is incremented by one.

CALL

Input:

STC | Labels | Subroutine name | Expression (arguments) | EOS

Output: Ptr to subroutine S.T. entry | Expression | Sub operator

Action: A symbol table entry is made (unless already present) for the subroutine name; a pointer to this entry is output. EXPR is called to output the argument list. Finally, the subscript/subroutine operator is output.

CLOSE

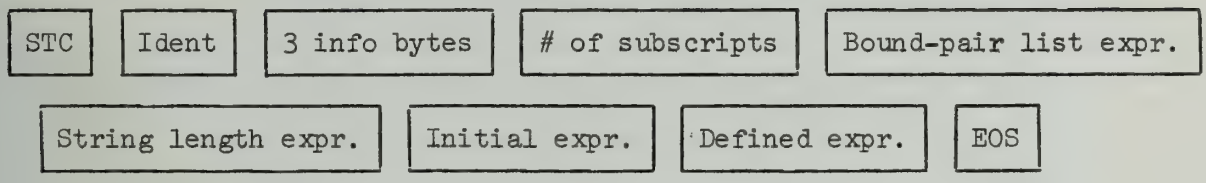
Input: STC | Labels | File name ... File name | EOS

Output: File name | Close operator ... File name | Close

Action: For each file name, an implicit symbol table search is made; if not found, an entry is constructed. A pointer to the entry is then output, followed by the close operator.

DECLARE

Input:



The information bytes following the identifier consist of bytes 0 and 2 for the symbol table followed by the byte:

BIT	0	Defined
	1	Initial
	2	External

Output: All expressions are transformed into strings of halfword symbol table pointers. The result is output into a special file for the declarations associated with the current block. The line number of this item is so constructed as to associate it uniquely with the correct block.

Action: A new symbol table entry is constructed for the identifier. Any expressions are analyzed without referring to the current block. The declaration file is searched for the identifier in the parameter list for a PROCEDURE block. If it occurs, the default attributes for the parameter are erased and the parameter declaration is linked to the (current) explicit declaration.

DO--Type 1

Input:

Output: none

Action: A block table entry is made.

DO--Type 2

Input: [STC] [Labels] [1] [Expression] [EOS]

Output: [Expression] [Label pointer] [Branch-if-false operator]

Action: A label constant is generated and left unresolved. A symbol table pointer for this label is output and is stored in the block table entry constructed for the type 2 DO iteration.

DO--Type 3

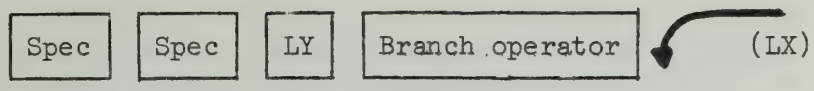
Input: [STC] [Labels] [2] [Index expr.] [Spec] ··· [Spec] [EOS]

Each specification consists of four expressions, with a null expression denoted by a zero byte. These are the Initial expression, the TO expression, the BY expression, and the WHILE expression.

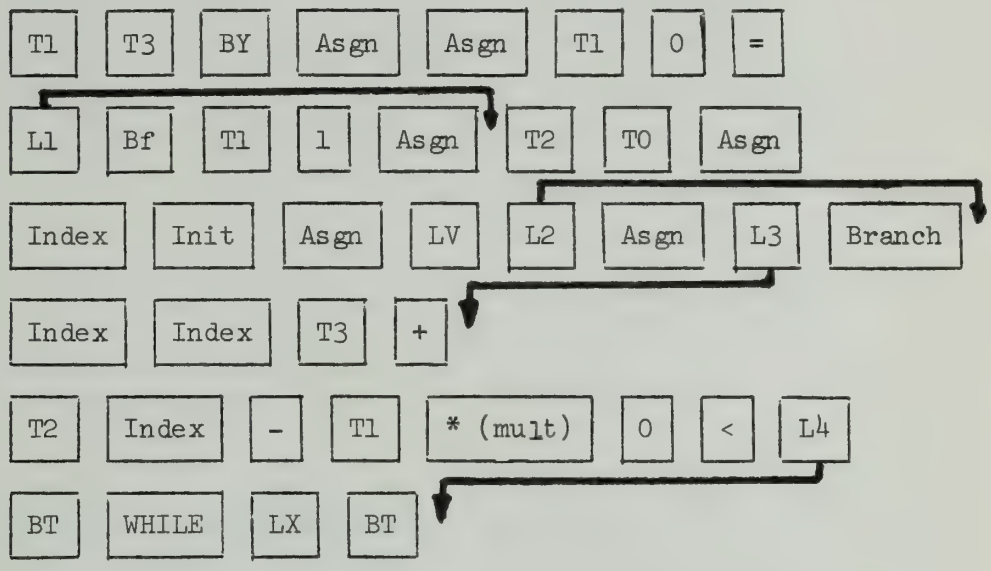
Remarks: T1,..., T_n are internally generated temporary variables; L1,..., L_n are internally generated temporary labels. LX is generated and pointed to the first position beyond the DO-generated code. LY is generated and left unresolved; when the corresponding END statement (q.v.) is encountered, LY is pointed beyond the END code. LV is an internal label variable. The code generated at END is equivalent to

END: GO TO LV; LY:;

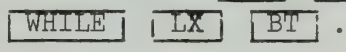
BT and BF are branch-if-true and branch-if-false operators.

Output: 

A specification with all four expressions present is output as:

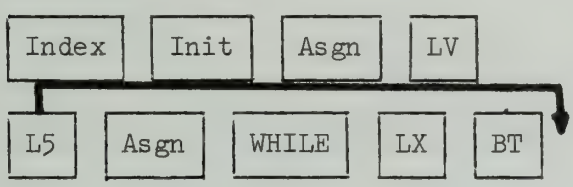


If the WHILE expression is missing,

will replace the final 

.

If the BY and TO expressions are missing, the output is simply



If BY is present but TO is omitted, the obvious simplifications are made.

Action: As indicated above, the DO statement is broken down into the equivalent of a set of simple statements. Thus for example,

DO I=A1 TO A2 BY A3 WHILE A4,B1 BY B3 WHILE B4;

is essentially recoded as

```
        DECLARE  LV  LABEL;
        T1, T3=A3; IF T1=0 THEN T1=1;
        T2=A2; I=A1; LV=L2; GO TO L3;
L2:  I=I + T3;
L3:  IF (T2 - I)*T1 < 0 THEN GO TO L4;
        IF A4 THEN GO TO LX;
L4:  T4=B3; I=B1; LV=L5; GO TO L6;
L5:  I=I + B3;
L6:  IF B4 THEN GO TO LX;
        GO TO LY; LX;
           .
           .
           .
END: GO TO LV; LY:;
```

END

Input: [STC] [Labels] [Identifier] [EOS]

Action: Action depends upon whether the identifier is present and what type of block (BEGIN, DO, or PROCEDURE) is current.

1. BEGIN block is current. Set bit indicating the block is closed, decrement level number, and perform appropriate action on declaration file.

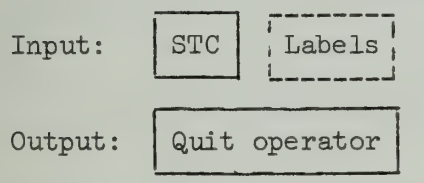
2. DO block is current. Close block and decrement level. For DO type 2, define label constant pointed to by block table entry. For type 3, output

[Label variable] [Branch operator], then define the label constant LY as in type 2.

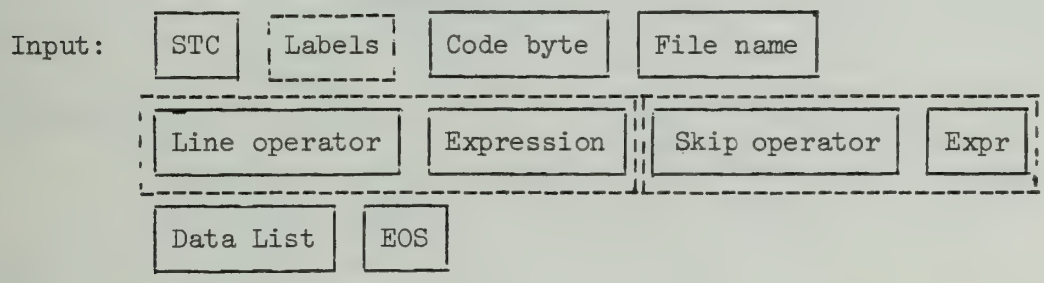
3. PROCEDURE block is current. Define label constant pointed to by block table entry, then proceed as with BEGIN block.

If the identifier is present in the END statement, the block stack is searched for the identifier. If found, all blocks from latest to earliest are closed as above.

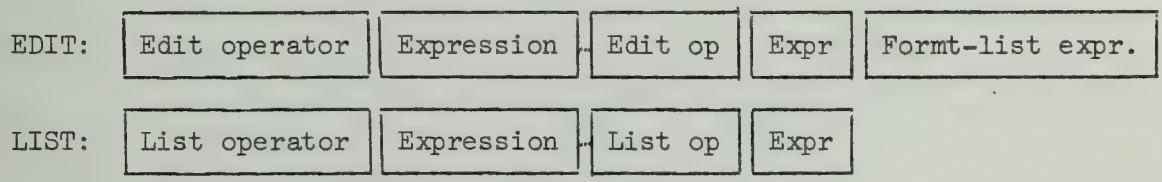
EXIT



GET/PUT



Where the data list is of either of these two formats:

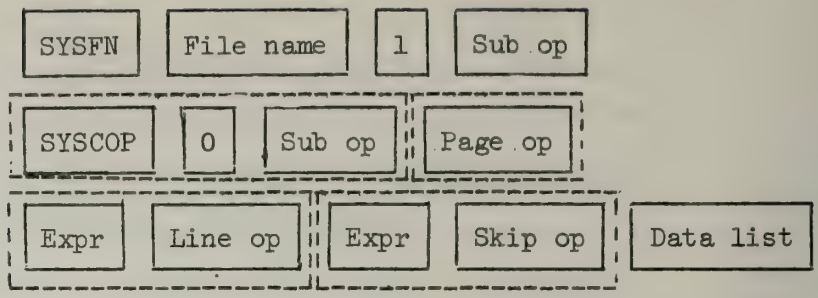


And the code byte includes

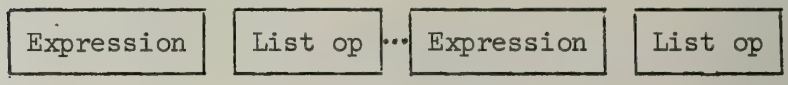
BIT	0=1	STRING name specified
	1=1	PAGE option specified (PUT only)
	2=1	COPY option specified (GET only)
	3=1	FILE name specified (or assumed)

The "file name" following the code byte may be a string name. The edit operators are Getedit and Putedit; list, Getlist and Putlist.

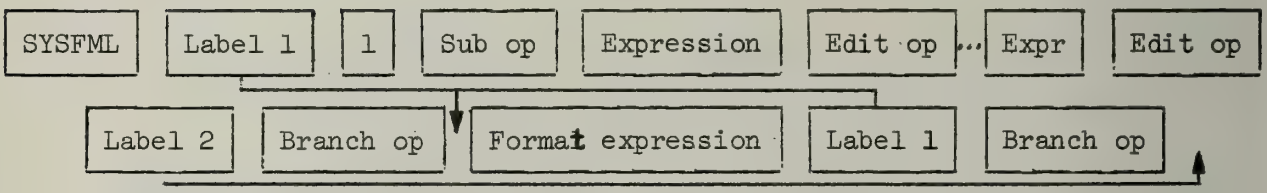
Output:



In the list directed case, the data list is simply:



In the edit directed case, things are rather more interesting:



Action: The GET/PUT routine assumes that, if no FILE or STRING was specified in the source, Pass I has inserted SYSIN or SYSPRINT as appropriate and turned on the FILE bit in the code byte. Thus, the first expression will always be present. The first item output will be CALL SYSFN (file name) or CALL SYSSTR (string name). If the COPY bit is on, a call to SYSCOP is then output. If the PAGE bit is on, the Page operator is output. If either SKIP or LINE appears, the expression for the number of lines is then output, followed by the appropriate operator (these two options are exclusive). Next the data list is scanned. It is to be noted that PL/I allows only one data list per statement; the GET/PUT routine, however, is designed to be unaware of this restriction. Output for the data list is as described above.

GO TO

Input: STC | Labels | Target label

Output: Target label | Branch operator

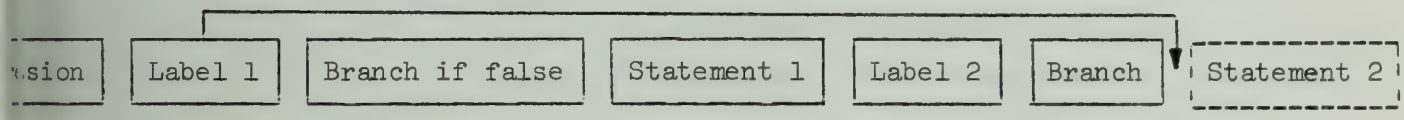
Action: obvious

IF

Input: STC | Labels | Expression | Statement 1

'ELSE' STC | Statement 2

Output:



Action: Label 1 and Label 2 are generated internally and resolved (pointed) as shown. Statement 1 and Statement 2 (if present) are handled by the appropriate statement routine.

OPEN

Input: STC | Labels | Option table | File name

Output: File name | Open operator

Action: The symbol table is searched for the file name. If found, the attributes in the symbol table are checked against those in the option table for compatibility. If not found, the appropriate entry is constructed, with a declaration in the current block.

PROCEDURE

Input: [STC] [Entry names] [SYMTAB info] [Type]

[String length] [Param] ... [Param] [EOS]

Output: [Label] [Branch] [Param] ... [Param]

Action: Each entry name is placed into the block stack and into the symbol table. The current Polish counter value is inserted into the symbol table entries. The Type byte contains bits for OPTIONS(MAIN) and RECURSIVE (the latter is automatic); this data is put in the symbol table. The string length is present only if the PROC is a string. The parameters are output into the Declaration file, with default attributes (which may be overwritten--see DECLARE). The Label is generated internally and is resolved when the corresponding END is encountered; this effects a branch around the procedure.

PUT

See GET.

RETURN

Input: [STC] [Labels] [Expression]

Output: [Return operator] or [Expression] [Ret. with value operator]

3.4 Display Processing Unit (R. Hostovsky)

In this quarter, major parts of the Display Processing Unit (DPU) have been designed. Details on this and overall descriptions of the system are presented in a Master's thesis by R. Hostovsky. The DPU is the interface between the PDP-8 memory and the rest of the display system.

The DPU retrieves data from the PDP-8 core memory, decodes it and generates picture information. This information is then transferred via a core memory buffer to a track of the central disk buffer, thus releasing the DPU for other tasks. The DPU performs the same functions that the DEC 338 does, with the additional capabilities of controlling and refreshing the picute at as many as 64 display terminals. Programming compatibility with DEC 338 is maintained except for two additional IOT's. All commands are transferred to the DPU via the PDP-8 single cycle data-break system. The programmer may specify which terminal he wishes to access at any time.

A special hardware scheme is used to generate the incremental commands from the combinations of codes which form lines and characters.

The order of execution of all the Control State instructions, PDP-8 display oriented instructions and the picture generation, is determined by a central control unit. The unit is composed of several sequential control points which govern the data flow in the DPU.

An interrupt queueing scheme controls the data communication between the display terminals and the DPU.

A central disk buffer holds the picture information for up to 16 display terminals, with a single track of the disk being dedicated to each of the terminals. Each of the tracks has its own read-head and line driver. The disk rotates at 30 revolutions per second, so the picture on each scope is refreshed at 30-cycle rate. This rate is high enough to give a flicker-free display. The display terminals can be remotely located from the central disk buffer. At the data rate used, 10^6 points/second are plotted by the display terminal.

The picture on each track of the disk is specified in terms of simple three-bit incremental command. These commands are decoded by a display control at each of the scope terminals where X-Y deflection signals are produced to position and display points. The commands allow the beam to be moved a certain number of units in any direction on a 1024 x 1024 grid (left-right, up-down, or diagonally) covering a 10" x 10" area on the scope face.

Information corresponding to the initial values of X and Y, four spot intensities, scale factor, P.B. enable, and joystick interrupt-enable are also stored on the disk. Zoom option information is transferred directly to the display terminal, so that frames may be expanded by a factor of two, four, or eight.

The operator of the CRT display can communicate immediately with the DPU and the PDP-8 processor by using the incremental joystick or the push-button control box.

The DEC 338, in order to generate typical pictures, uses about 30,000 moves per frame, and the picture has to be reconstructed and regenerated 30 times per second to avoid excessive flicker. Also, the 338 may access the PDP-8 via the data-break system only once in three PDP-8 memory cycles, degrading the speed of generating points and vectors which results in lower picture capacity. The DPU disk buffer contains about 100,000 bits or 33,000 instructions in a full track. A track of data corresponds to a picture containing 660" of drawing. This means 66 screen widths of horizontal or vertical lines (in scale of 2), or about 1500 characters, or a proportional mix.

Consequently, the DPU-disk configuration with its independent picture refreshing capability, easily handles display files like those executed by the DEC 338.

By sharing the disk-memory among several display units, the cost-per-terminal is reduced by a considerable amount.

3.5 Computer Maintenance and Construction (C. Carter, W. Hromadnik, R. Miller, H. Lopeman)

The disk has been re-installed and running most of this quarter. Several experiments in timing and logic have been done in an effort to improve reliability. Good results are being obtained now with a respectable error rate. There is a definite relationship between the number of errors and the temperature in the cabinet. At this time, a method is being devised to control the cabinet temperature.

The Sylvania Data Tablet was received and tested. It was found to be defective and alignment was off by some great amount. The tablet was returned to the factory and has since come back to the Department. The defect was reparied, but the alignment is still bad. An attempt will be made to get a factory representative out to align the tablet.

The PDP-8 expander cabinet has arrived and will be installed to clear up the interface problem on the PDP-8 and allow room for the PDP-8-2701 interface.

There were numerous cables run from the PDP-7/630 complex to various room in D. C. L. This will enable TTY hookups from more areas than has been possible previously.

TTY maintenance and modifications include:

1. Overhaul--3 TTY Mod. 33 completely overhauled
   3 TTY Mod. 33 partially overhauled
2. Repair--17 TTY Mod. 33
3. Modifications--3 TTY Mod. 33's were modified for acoustical couplers

Form AEC–427
(6/68)
AECM 3201

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QUARTERLY REPORT (April, May, June)

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and Principle Investigator

Organization

Department of Computer Science
University of Illinois
Urbana, Illinois 61801

Signature: Charles W Gear.

Date: June 1969

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4. ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III
(Supported in part by Contract AT(11-1)-1018 with the U. S. Atomic Energy Commission and the Advanced Research Projects Agency)

SUMMARY OF ACHIEVEMENTS
DURING CONTRACT YEAR

Illiac III Computer System

Illiac III is an experimental computer being designed and constructed by the Department of Computer Science as a first instrument to explore the potentialities of high speed image processing. Major accomplishments this contract year include:

a. Construction of Scan/Display Center allowing bypass communication with the service IBM 360/75 computer.

b. Specification of the Taxicrinic Processor and the interface of this processor with the Operating System.

c. Design of the high speed Arithmetic Units.

d. Design of the I/O Channels of the Illiac III System.

Pattern Recognition Theory

a. The discovery of the concept of name-independent picture parses.

b. First prototype investigation of the game theory of image processing.

c. First lattice-theoretic definition and algebraic classification of graph transformational grammars.

4.1 HARDWARE DEVELOPMENTS

The Illiac III Computer System can be described in terms of 14 constituent subsystems of processors, units and peripheral device groups as follows (see Figure 1):

i) Central System (6 subsystems)

ii) I/O System (3 subsystems)

iii) Peripheral System (4 subsystems)

iv) Power Distribution System (global to all subsystems).

Only one, the Fast Core Storage Modules, is of commercial design. The other constituent subsystems have been designed almost entirely as part of the graduate research program of the Department of Computer Science.

This massive design/development program was not undertaken lightly. Rather, central to the contract program has been the study of the computer architecture appropriate for high speed image processing. These peripheral devices, units and processors must be able to talk to one another -- and with minimum data format conversion: the Scanners feed the Pattern Articulation Unit, whose output in turn is interpreted by a Taxicrinic Unit. This global integration of the design has been costly but integral to the integrity of the system design presented here.

Each following section summarizes briefly on constituent subsystem: Taxicrinic Processor, Arithmetic Unit, etc. In general a function description is followed by a discussion of special design features (if any), available documentation, and finally by a design/hardware status report (in a standardized bar graph form). Documentation listed is that printed during the current contract period with the exception of an occasional listing of an earlier report as required for conceptual continuity.

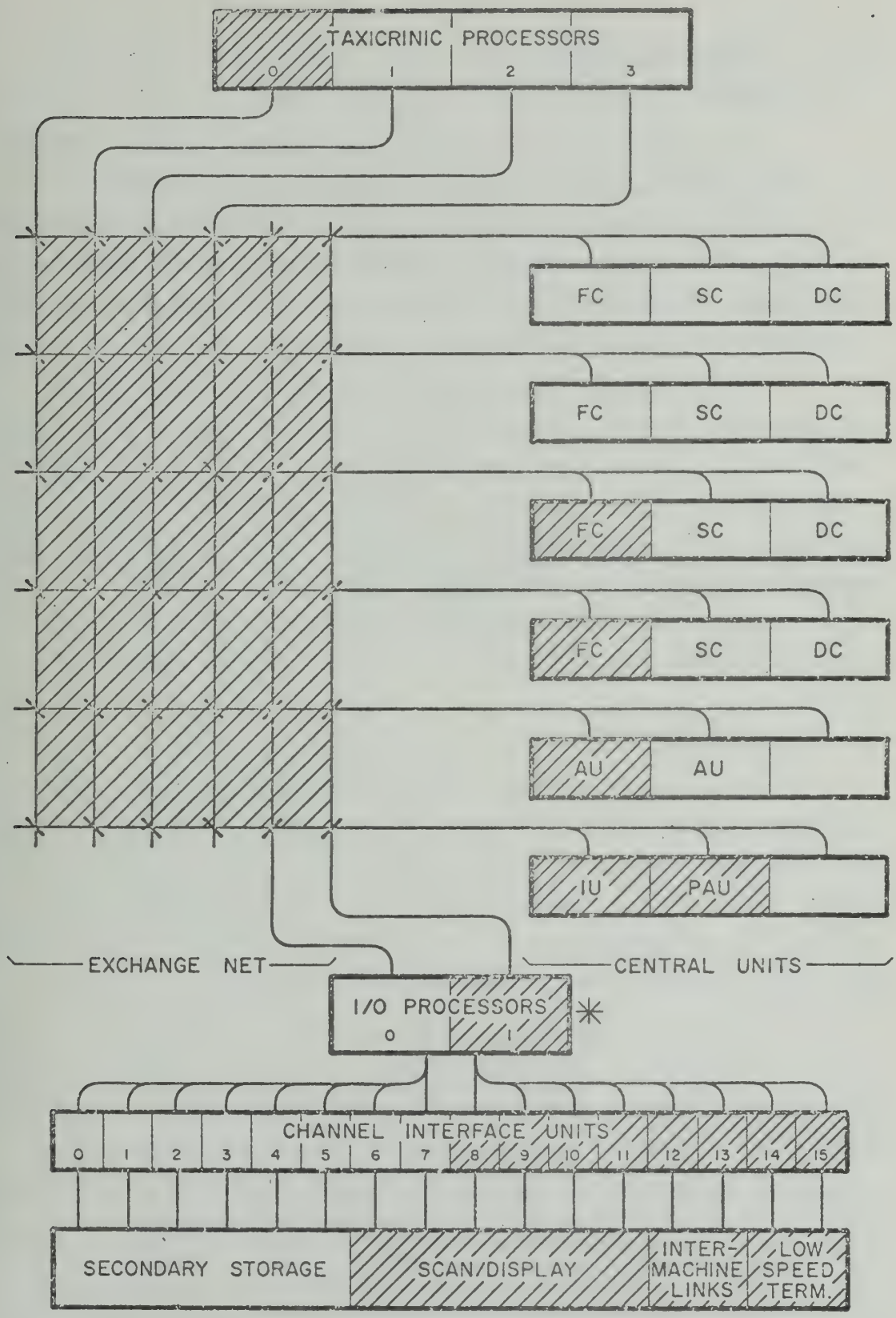


FIGURE 1 - SCHEMATIC OF ILLIAC III COMPUTER (THE MINIMUM MACHINE)

* Highly restricted initially

4.1.1 Taxicrinic Processors

4.1.1.1 Function

The Taxicrinic Processors are the central control units of Illiac III. The Taxicrinic Processors are primarily responsible for the execution of user programs, that is, to oversee the operations of the Pattern Articulation Unit, the Arithmetic Unit and to initiate input/output operations in the I/Ø Processors by making requests to the Interrupt Unit.

The principal activity of a Taxicrinic Processor is the manipulation, search and systemization of abstract graphs (bilateral list structures) which have been produced from the pictorial input to the Pattern Articulation Unit. The name "Taxicrinic" comes from two Greek words: ταξις meaning "arrangement" or "pattern", and ταξις meaning to "judge", thus indicating the TP's general purpose, which is to syntactically analyze digitized pictures and other material which can be cast into the form of a directed,labeled graph.

4.1.1.2 Design Features

The Taxicrinic Processors can address operands in either a paged or unpaged (contiguous storage) environment. Automatic reference to the Segment Name Table insures that operands are always referenced in a completely relative (relocable) manner. Pointer stacks are provided to expedite addressing of trees (i.e. "structures" in PL/1 notation) and to permit automatic nested macro calls (see below).

Central to the design is the capability of the TP to execute a class of procedure calls (and returns) entirely in hardware -- including the mapping of actual onto formal parameters (operands). This facility means that i) extensive use can be made of read-only memory -- of particular advantage in a time-sharing system, and ii) an interpretative translation procedure can be used efficiently to implement, for example, an extensive list processing repertoire.

List processing has also been designed into the processor by including instructions for the control of Available Space, and for the insertion/deletion of a list cell.

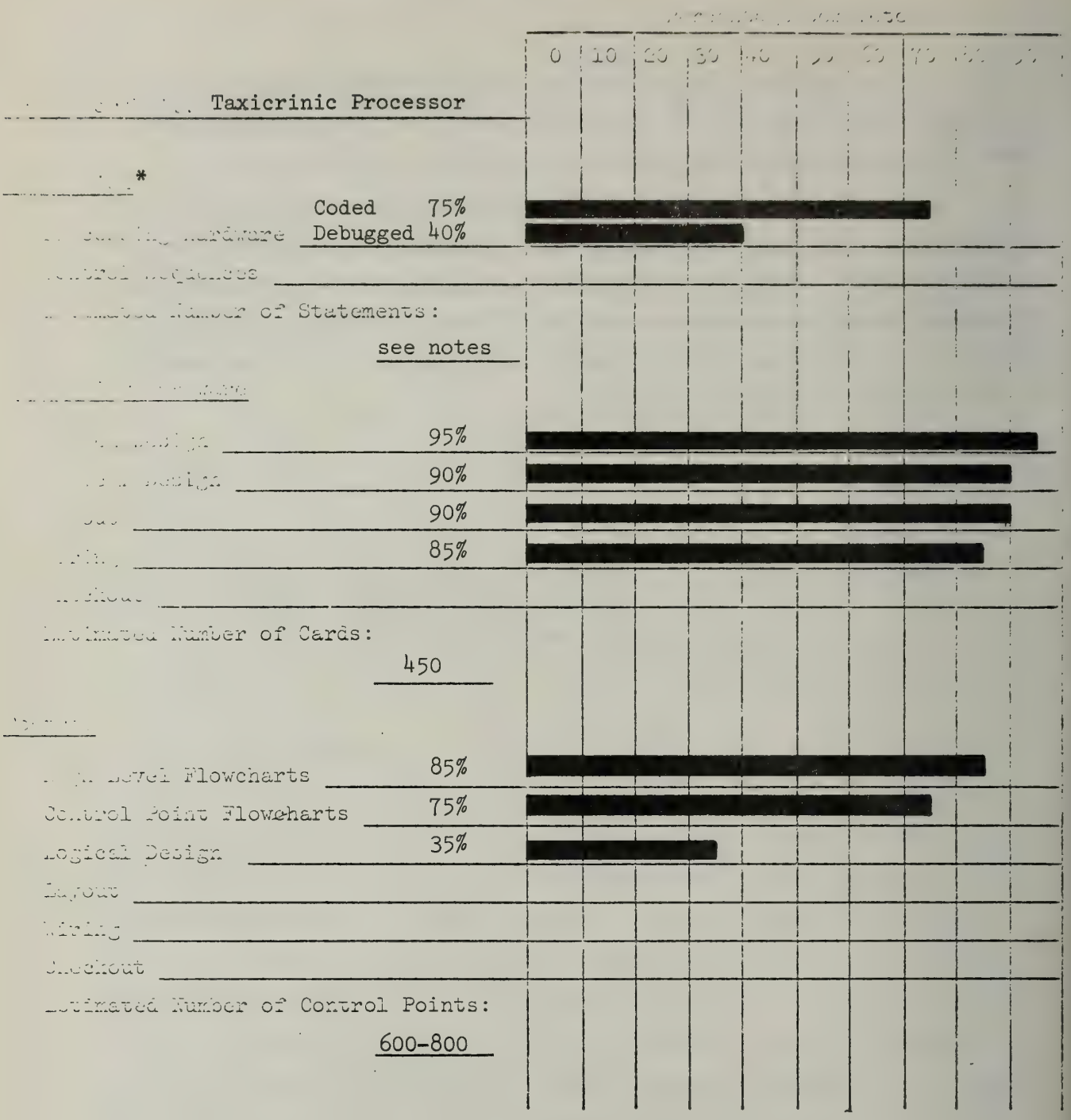
In addition the TP must interpret Pattern Articulation Unit instructions, much as a more conventional CPU must communicate with an Arithmetic Unit. Where possible operand transmittal has been based upon buffering in the Operand Stack of the Taxicrinic Processor, an array of 32 bytes of fast storage with automatic refill/unload facilities coupling to that portion of the stack in core.

4.1.1.3 Documentation

Report

Report No. 341 — Nordmann, Bernard J. Nordmann, "Illiac III Computer System Manual - Taxicrinic Processor (TP)", Volume 1, July 1969.

4.1.1.4 [illegible]



Percentages refer to the TP Logic Simulator. A previous instruction-level simulation, consisting of 5000 assembly language instructions, was completed to correspond to the machine of Summer 1967.

Processing Logic Simulation currently comprises ~1000 statements.

Control Logic simulation employes an interpretive subroutine to simulate the action of the control points. This code is expected to run ~500 statements. The control sequences, as read directly off control point level flowcharts might run as high as 2500-3000 statements.

4.1.2 Fast Core Storage Units

4.1.2.1 Function

Two Fast Core Storage Units are presently used in the Illiac III system. Each module has a capacity of 16,384 memory words and a cycle time of 700 μsec.

The standard memory word is 80 bits, consisting of 64 data bits, 8 flag bits and 8 parity bits. This corresponds to an Illiac III double-word cell, augmented by parity bits. Each memory word is divided into eight byte zones which may be read and/or written independently of one another.

4.1.2.2 Status

Each unit is a self-contained assembly consisting of all registers, timing circuits, power supplies and interface circuitry necessary for operation of the system and compatible with the Illiac III environment. The two units described above were built under subcontract by Fabri-Tek, Inc. and are now operational.

4.1.3 Arithmetic Units

4.1.3.1 Function

Two identical Arithmetic Units (AU) perform most arithmetic operations in the Illiac III system. Integer addition and subtraction, as well as several unary operations form exceptions and are actually executed in the Taxicrinic Processors.

The prime responsibility of the Arithmetic Units is the high-speed execution of floating point arithmetic operations. The units also provide facilities for integer multiplication and division and conversions from one number-type to another, e.g., floating to long fixed.

As in the case with all other units of the system, communication with the processors is via the Exchange Net.

The Exchange Net assigns an AU to a requesting processor and also returns the results of an arithmetic operation to the processor which initiated the operation. Figure 1 illustrates the location of the AU's in the overall system.

The execution of an arithmetic instruction begins in a Taxicrinic Processor. The operands are assumed to be in the top of the operand stack of the TP. Upon completion of the arithmetic operation the result is returned to the operand stack of the initiating TP.

4.1.3.2 Design Features

In keeping with the experimental nature of the Illiac III, the arithmetic units are intended to be a practical testing ground for recent theoretical work in computer arithmetic. Their design uses redundant number systems and a structure in which multiplication and division are executed radix 256. The heart of the unit is the stored-sign subtracter, a recently discovered member of the family of borrow-save subtracters and carry-save adders. A cascade of these subtracters controlled by a multiplier recoder, provides multiplication. The same structure, controlled by a "model division" (a quotient recoder), performs division.

4.1.3.3 Documentation

Publication	Atkins, Daniel E., "Higher-Radix Division Using Estimates of the Divisor and Partial Remainder", IEEE Transactions on Electronic Computers, Vol. C-17, No. 10, October 1968.
Report	
Report No. 330	Atkins, Daniel E., "Design of the Arithmetic Units of Illiac III: Use of Redundancy and Higher Radix Methods", May 1969.
Report No. 290	Koo, Ping L., Atkins, D.E., "Arithmetic Unit of Illiac III: Simulation and Logical Design-Part II", October 28, 1968.
File Number	
File No. 713	Atkins, Daniel E., "Arithmetic Unit of Illiac III: Simulation and Logical Design - Part I, September 27, 1966.

Volume I of the Arithmetic Unit Manual has been largely completed and is in the final editing stages. This volume (approximately 200 pages) covers the details of the processing structure (the total logic exclusive of control).

A report describing the more theoretical aspects of the arithmetic unit was prepared for presentation at the Workshop on the Theory of Computer Arithmetic, Third Annual IEEE Computer Conference (Minneapolis). This paper, DCS Report No. 333, describes the use of redundant number systems and the design of a structure with which multiplication and division are executed radix 256. A manuscript has been submitted to the IEEE Transactions on Computers for publication in a special issue devoted to the arithmetic workshop.

Percentage Complete

	0	10	20	30	40	50	60	70	80	90
Number and Name: Arithmetic Unit										
Definition										
Processing Hardware 100%	■	■	■	■	■	■	■	■	■	■
Control Sequences 100%	■	■	■	■	■	■	■	■	■	■
Estimated Number of Statements: 1800										
Detailed Hardware										
System Design 100%	■	■	■	■	■	■	■	■	■	■
Logical Design 100%	■	■	■	■	■	■	■	■	■	■
Layout 100%	■	■	■	■	■	■	■	■	■	■
Wiring (1 AU only) 100%	■	■	■	■	■	■	■	■	■	■
Checkout										
Estimated Number of Cards: 475										
Control										
High Level Flowcharts 100%	■	■	■	■	■	■	■	■	■	■
Control Point Flowcharts 1st pass 100%	■	■	■	■	■	■	■	■	■	■
Control Point Flowcharts 2nd pass: 60%	■	■	■	■	■	■	■			
Logical Design 40%	■	■	■	■						
Layout										
Wiring										
Checkout										
Estimated Number of Control Points: 130										

Notes:

4.1.4 Pattern Articulation Unit

4.1.4.1 Function

Image processing can be reduced to the study of those sequences of basic, or root, instructions which permit recognition and description of the input image. These basic instructions can then be implemented in a processor designed specifically for that purpose. Here the duty of the Pattern Articulation Unit (PAU) is to perform local preprocessing on the input from the scanners, such as track thinning, gap filling, line element recognition, and so forth. The logical design of this all-digital processor has been optimized for the idealization of the input image to a line drawing. Nodes representing end points, points of inflection, points of intersection, and so forth, are labeled in parallel by appropriate programming under overall supervision of a control, or taxicrinic, processor. The abstract graph describing the interconnection of labeled nodes is then extracted as a list structure, which comprises the normal output of the processing unit.

4.1.4.2 Design Features

The PAU employs a two-dimensional Iterative Array (IA) of 1024 (32 x 32) identical processing modules locally connected to execute Boolean functions, threshold logic, and signal path building. It is augmented by its own control unit and by an unconventional core memory, called the Transfer Memory (TM), which in conjunction with the Iterative Array, can operate as an associative memory.

4.1.4.3 Documentation

Report

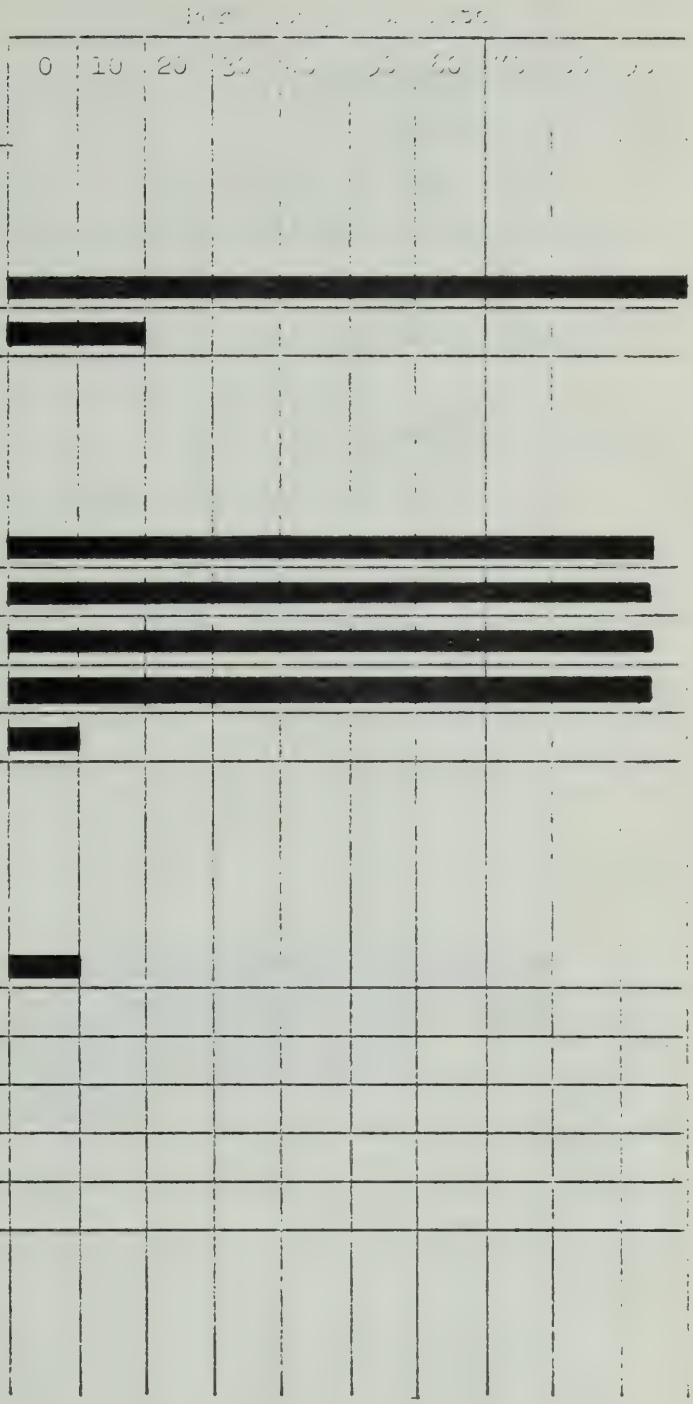
Report No. 338 — Borovec, Richard T., "The Pattern Articulation Unit of Illiac III: Hardware Implementation of the Homogeneous Instruction "BOOLE", June 20, 1969.

Report No. 285 — Koo, Ping L., Borovec, Richard T., "The Pattern Articulation Unit of Illiac III Simulation: Part I, Iterative Array Transfer Memory, BOOLE Control", September 20, 1968.

Report No. 253 — McCormick, B.H., Watson, W.J., Borovec, Richard T., "The Pattern Articulation Unit of Illiac III: Homogeneous Boolean Functions in the Iterative Array", January 8, 1968.

4.1.4.4

Pattern Articulation Unit



Coding Hardware 100%

Control Sequences 20%

Estimated Number of Statements: 700

System Design 95%

Logical Design 95%

Layout 95%

Wiring 95%

Checkout 10%

Estimated Number of Cards: 1800

*

High Level Flowcharts 10%

Control Point Flowcharts

Logical Design

Layout

Wiring

Checkout

Estimated Number of Control Points: not applicable

*Microprogrammed control is planned except for the BOOLE instruction realization.

4.1.5 Interrupt Unit

4.1.5.1 Function

The Interrupt Unit (IU) of Illiac III is a message store-and-forward processing unit through which all processor-processor communication takes place. In addition certain system-wide facilities, e.g. system accounting clock, etc., are maintained by the unit.

4.1.5.2 Documentation

Two DCS file notes are in draft form: "Design Considerations for the Interrupt Unit of Illiac III" by R. M. Lansford and L. N. Goyal and "A Hardware Realization of the Interrupt Unit of Illiac III" by R. M. Lansford and L. N. Goyal.

4.1.5.3 [illegible]

Interrupt Unit

*

[illegible] Hardware

[illegible] Sequences

[illegible] Number of Statements:

[illegible]

[illegible] Design 90%

[illegible] Design 60%

[illegible] 20%

[illegible] 10%

[illegible]

[illegible] Number of Cards:

25 I.C. Cards

[illegible]

[illegible] Level Flowcharts 80%

[illegible] Point Flowcharts 80%

[illegible] Design 60%

[illegible] 20%

[illegible]

[illegible]

[illegible] Number of Control Points:

40

[illegible]:

*Simulated as indirectly as called by the TP and IØP simulations.

4.1.6 Exchange Net

4.1.6.1 Function

The Exchange Net is depicted in Figure 1 as having six Processor ports and eighteen Unit ports. The purpose of the Exchange Net is to provide a 50-bit Processor-to-Unit information path and a 50-bit Unit-to-Processor information path for every possible Processor-Unit pair.

4.1.6.2 Documentation

File Number

File No. 790	Krabbe, S. Paul, "A Discussion of Illiac III Processor-Unit Communiction Via the Exchange Net", March 8, 1969.

: Exchange Net

[illegible]

[illegible] Hardware

[illegible] Techniques

[illegible] Number of Statements:

[illegible]

[illegible]

[illegible] Design 100%

[illegible] Design 100%

[illegible] 100%

[illegible] 90%

[illegible]

[illegible] Number of Cards:

912

[illegible]*

[illegible] Level Flowcharts*

[illegible] Point Flowcharts*

[illegible] Design 100%

[illegible] 100%

[illegible] 90%

[illegible]

[illegible] Number of Control Points:

0

[illegible]applicable. Control point strategy was not used in the Exchange Net.

4.1.7 I/O Processors

4.1.7.1 Function

An Input/Output Processor (IØP) directly controls all input/output operations on the 8 channels under its jurisdiction. Each of the 8 channels operates similarly to a selector channel while the IØP directs their operation in a multiplexing fashion.

The IØP control is divided into two parts: the Task Subprocessor (TSP) and the Channel Subprocessor (CSP). The Task Subprocessor controls the sequencing of tasks within the I/O Processor, the handling of the various interrupts, and the execution of device independent commands (DIC's). The Channel Subprocessor handles the execution of device dependent commands (DDC's); thus it controls the information exchange with the Channel Interface Units (CIU's) and initiates memory access requests when data transfer is required.

4.1.7.2 Design Features

The IØP design accommodates very high data rates (up to 10 megabits per second is required for scanner data). Prior to the initiation of any data transmission command, the IØP determines whether or not sufficient channel capacity remains to insure that the maximum IØP data rate is not exceeded by adding this device's data to that already being handled.

In addition to conventional block data transfers the IØP permits I/O data to be in a linked list format in core memory. Another feature of the IØP design is the capability of controlling from a single I/O program the operations on up to 3 different channels.

Percentage Complete

0 10 20 30 40 50 60 70 80 90 100

Unit Title: I/O Processors

Unit *

Processing Hardware

Control Sequences

Estimated Number of Statements:

Unit Status:

Work Design 80%

Logical Design 50%

Layout

Wiring

Checkout

Estimated Number of Cards:
450

Unit Status:

High Level Flowcharts 80%

Control Point Flowcharts 60%

Logical Design

Layout

Wiring

Checkout

Estimated Number of Control Points:
350

Comments:

*The general I/O structure was simulated by G. Cederquist in 1967 and the control flowcharts for the proposed register structure was simulated by L. Katoh during the first quarter of 1968; however, no simulation has been done on the present form of design.

4.1.8 Channel Interface Unit

4.1.8.1 Function

A Channel Interface Unit (CIU) provides 3 words of buffering between the very fast I/Ø Processor and the relatively slow peripheral devices. In conjunction with this buffering function the CIU provides the necessary interface control signals to the device controller for all data transfers, and it properly formats this data as it flows in and out of its buffers. The CIU also insures that the control signals to the device controller occur in the proper time sequences, as defined in the IBM System/360 Interface Manual.

Report Date: [illegible]

Unit Title: Channel Interface Units

Unit No.: *

Receiving Hardware

Control Sequences

Estimated Number of Statements:

Transmitting Hardware

System Design 95%

Logical Design 90%

Layout 60%

Wiring

Checkout

Estimated Number of Cards: 70

Control

High Level Flowcharts 85%

Control Point Flowcharts 70%

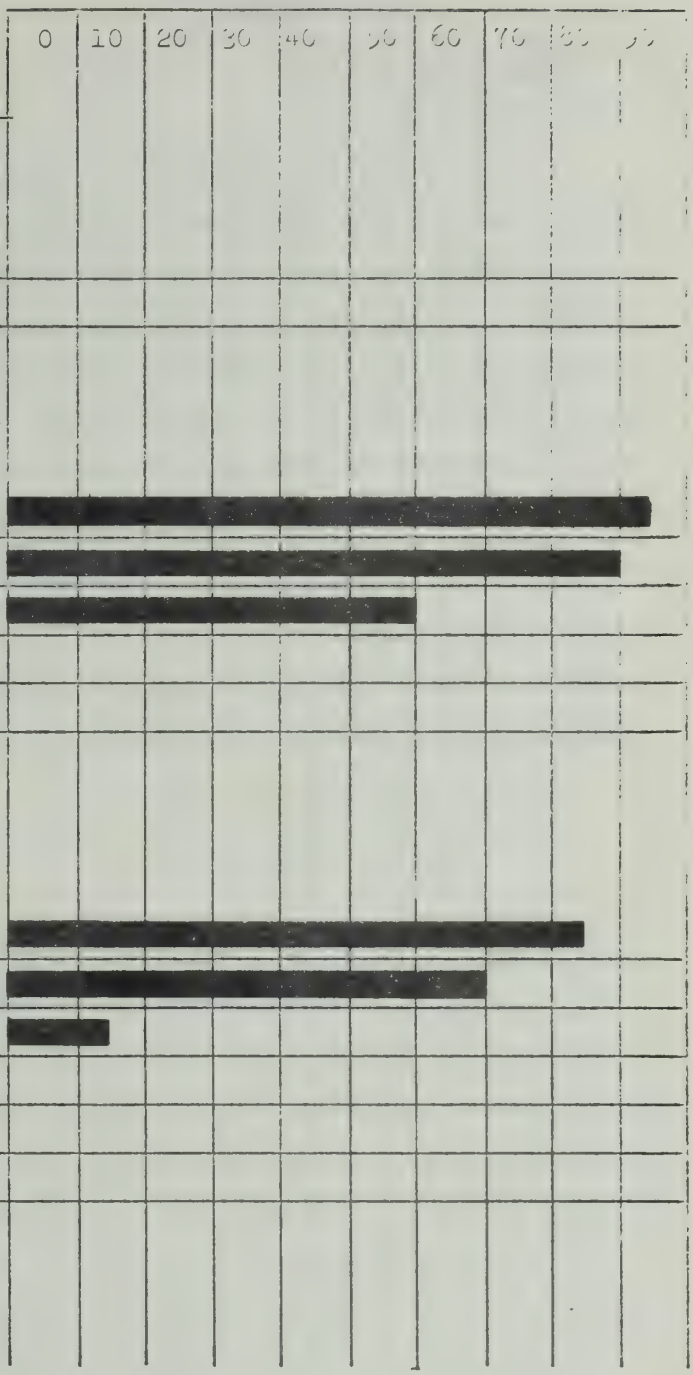
Logical Design 15%

Layout

Wiring

Checkout

Estimated Number of Control Points: 60



*Extensive simulation has been done by J. Hayes during 1967 on the form of the CIU that existed at that time.

4.1.9 Device Controller

4.1.9.1 Function

A Device Controller (DC) provides the proper interface control signals between the peripheral devices and the I/Ø channel. With respect to the channel the Device Controller affords the standard IBM System/360 Interface. With respect to the peripheral device the Device Controller assumes the task of decoding the various control signal sequences, but enough flexibility is allowed to enable the peripheral device to control such DC features as mode of operation (multiplex or burst) and the suppressibility of device data.

4.1.9.2 HARDWARE STATUS REPORT

Percentage Complete

	0	10	20	30	40	50	60	70	80	90	100
Designer/Unit: Device Controller											
Definition											
Processing Hardware 0%											
Control Sequences 0%											
Estimated Number of Statements:											
Building Hardware											
System Design 80%	■	■	■	■	■	■	■	■			
Logical Design 30%	■	■	■								
Layout											
Wiring											
Checkout											
Estimated Number of Cards: 10 I.C. Cards											
Logic											
High Level Flowcharts 90%	■	■	■	■	■	■	■	■	■	■	
Control Point Flowcharts 60%	■	■	■	■	■	■					
Logical Design											
Layout											
Wiring											
Checkout											
Estimated Number of Control Points: 60											

Comments:

4.1.10 S-M-V Controller

4.1.10.1 Function

A new direction in image acquisition and display is to append a Video Communications Net to the central computer so as to provide the remote users with video communication to a centralized image processing facility. In addition to facilities for the acquisition of pictorial information, there is also a need for interactive display systems to present both intermediate and final processed data. The subject of graphic display terminals has been extensively discussed in the literature. Scan-display systems oriented towards image processing, however, with particular attention to bypassing the central processing unit for as many tasks as possible, have not had comparable development. The system described below, called the 'Scanner-Monitor-Video' (SMV) system of Illiac III, is focused on this latter area. Central to this system is the S-M-V Controller.

4.1.10.2 Design Features

Figure 2 shows the system as it has evolved. High resolution scanners allow the scanning of the film for accurate measurement purposes and also allow the construction of images on film. High resolution monitors are slaved to the scanner system in a manner which allows the monitors to borrow inexpensively the scanner control. The video switching matrix provides the closed circuit television facilities for remote users. High resolution CCTV cameras are provided for image encoding and acquisition. Remote video consoles, consisting of two high resolution monitors and a teletype set, provide information display at the remote user's end. The Videograph printer outputs a fascimile copy at the rate of one sheet every 0.8 seconds, where the copy can have any admixture of text, graph or halftone pictures. Video images can be treated as if they were on film and thus the same encoding techniques and the same programs could be exploited for both without program change. The character generator provides facilities for message handling and display in general, particularly for CAI, which along with the scanner provides the flexibility of displaying line drawings and half tone pictures intermixed with the text. More details about the devices shown in Figure 2 are given in Section 1.11.

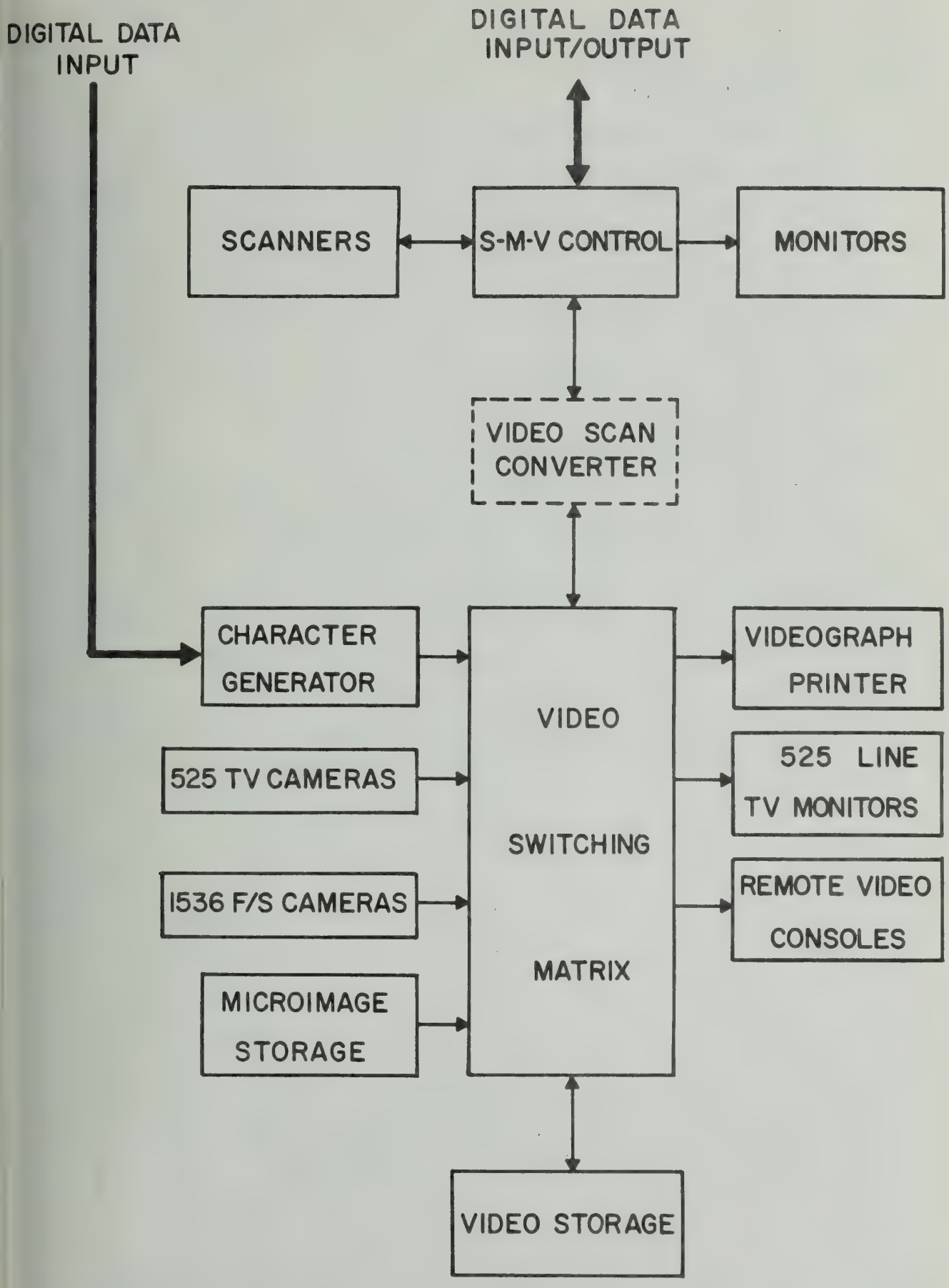


Figure 2 - Block Diagram of the Scan/Display System. Note that the Video Scan Converter can be bypassed under program control.

4.1.10.3 Prototype Scanner

A simplified scanner has been built as a means of testing various logic and analog portions of the final SMV system. The simplified scanner scans a 512 x 512 raster in one of 64 selected areas of the object film, packs the gray level information into 32 bit words and stores this information in one of the Fabri-Tek memories. The same logic permits the stored information to be extracted, decoded and displayed on a monitor. The system is operational, but is now being dismantled for replacement by the final S-M-V system.

4.1.10.4 Interim Scan/Display System

Under the current contract a link between a scanner/monitor of Illiac III and the IBM 360/75 is being established. This link utilizes the full Scanner-Monitor-Video Controller[1] as described in the presentation at the Spring Joint Computer Conference 1969. Scanned data is transmitted through the Exchange Net to the fast core modules of Illiac III. Data can then be transmitted first to the PDP-8, then exploiting a previously established graphics connection[2] between the PDP-8 and the IBM 360/75, data can in turn be transmitted to the service computer, the IBM 360/75. This "interim" scan/display system is illustrated in Figure 3.

---

1. Dunn, L.A., et.al., "Parametric Description of a Scan-Display System", Department of Computer Science Report No. 308, February 5, 1969.

2. Supported under Contract AT(11-1)-1469 with the AEC.

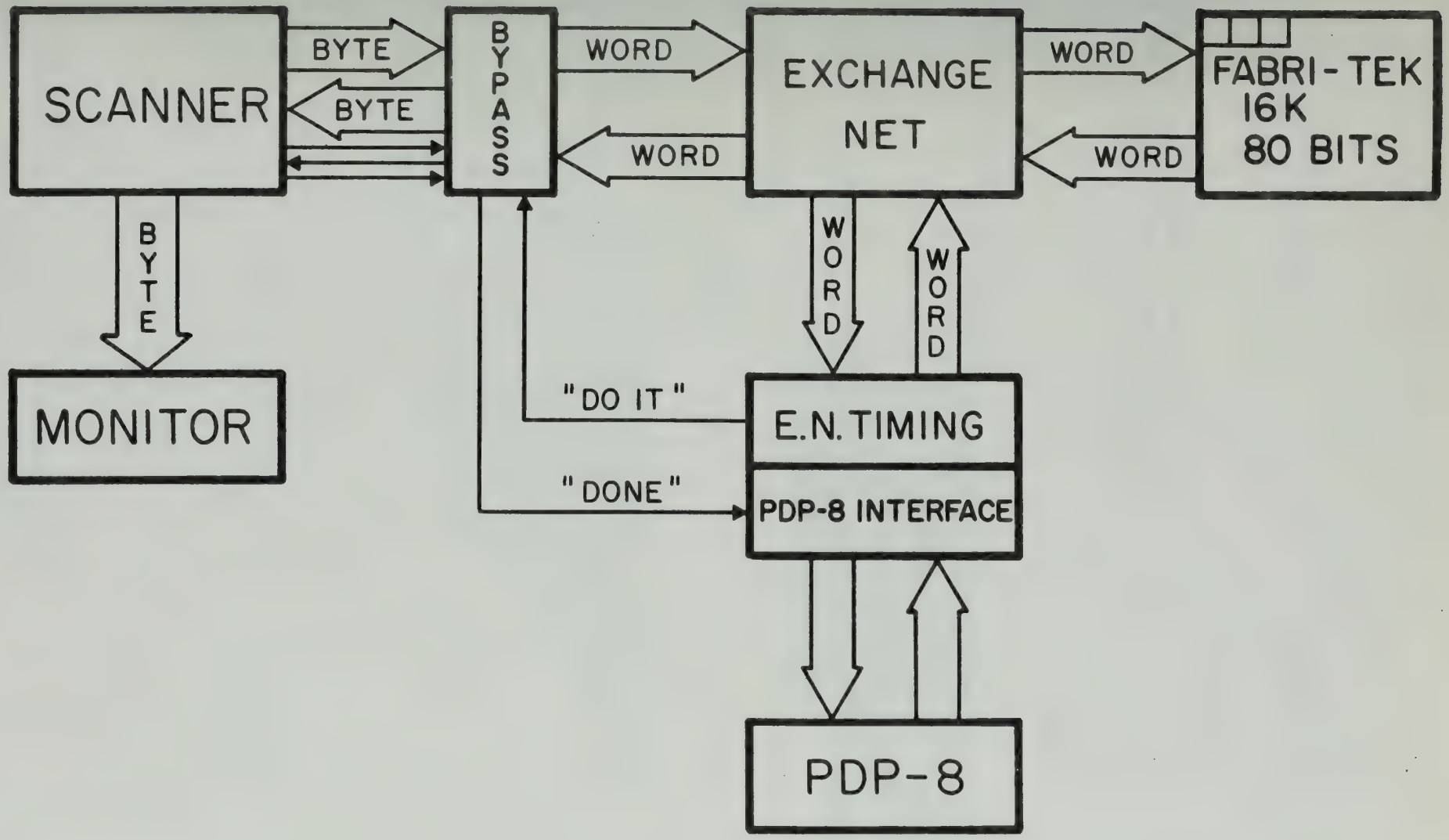


Figure 3 - Interim Scan/Display System

4.1.10.5 Documentation

Publication

Dunn, L.A., et.al., "Parametric Description of a Scan-Display System", AFIPS Conference Proceedings, Vol. 34, p. 187-206.

Report

Report No. 320 — Divilbiss, J.L., "Illiac III Scanner Analog Circuits", April 10, 1969.

4.1.10.6 HARDWARE STATUS REPORT

Percentage Complete

0 10 20 30 40 50 60 70 80 90 100

Sector/Unit: S-M-V Controller

mulation

Processing Hardware

Control Sequences

Estimated Number of Statements:

cessing Hardware

System Design 90%

Logical Design 90%

Layout 90%

Wiring 90%

Checkout 60%

Estimated Number of Cards:

220

Level

High Level Flowcharts 80%

Control Point Flowcharts 60%

Logical Design 50%

Layout 40%

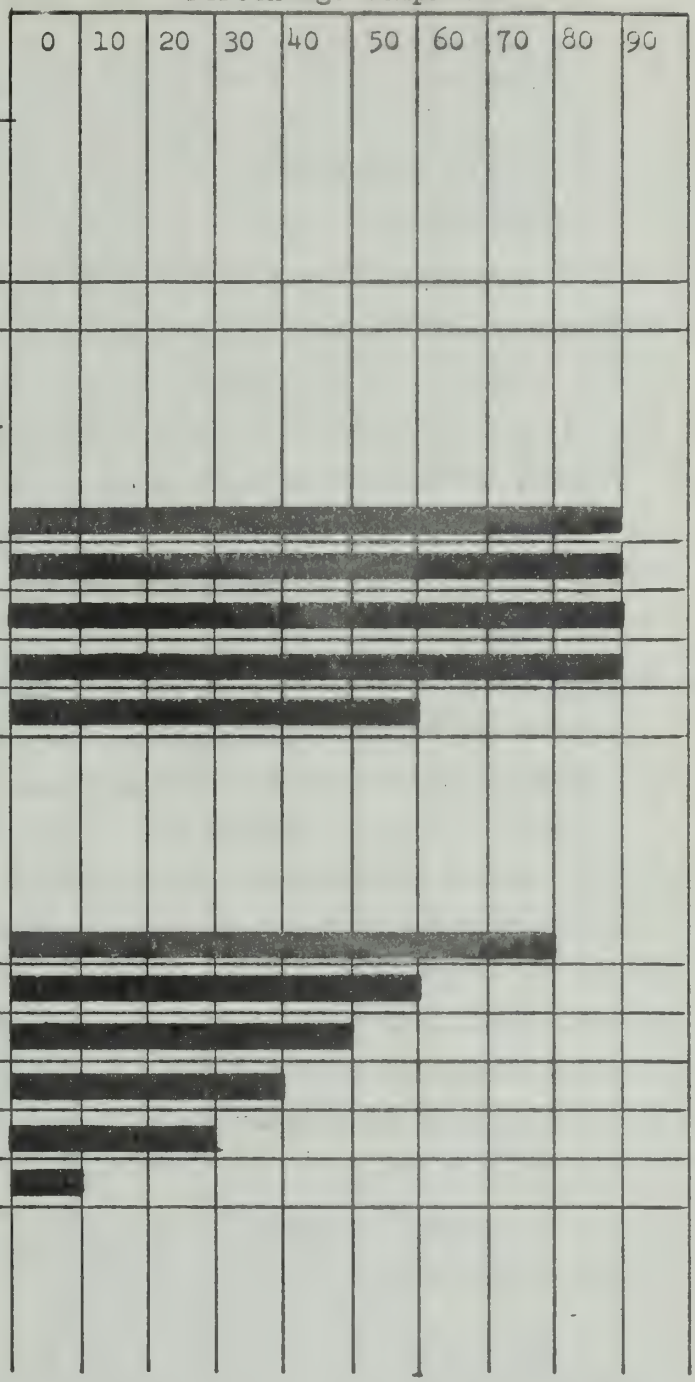
Wiring 30%

Checkout 10%

Estimated Number of Control Points:

250

ks:



4.1.11 Scan-Display Devices

4.1.11.1 Scanners

The scanners are flying spot scanning systems with an added diquadrupole coil for astigmatic defocusing of the spot into a line element to achieve a slit mode. All scanners are capable of either scanning from developed film or photographing onto unexposed film. The optical path of the beam is split, with one path transversing the film and the other path through a reference grid to establish stability against engraved fiducial marks.

Several types of media transports are provided to handle the projected range of problems. A 70 mm. scanner is provided primarily for 70 mm. negative bubble chamber film. Here the format of the raster is 2.362 inches x 3.522 inches, and the minimum spot size is approximately 0.001 inch at the film. Due to the length of the frame to be scanned, scanning is done in two steps. The two horizontal halves of the frame are scanned successively with a 4 mm. overlap to establish half-frame continuity. Large motors are used for slew and gross positioning of the film and a small digital stepper motor is used for fine positioning of the frame. Frame position sensing is accomplished by using the digital stepper motor as a tachometer and by counting sprocket holes. Total film capacity is 1000 feet.

A scanner for handling 47 mm. film is similar to the 70 mm. transport design except for the following:

The film format is different. A friction drive is used on the digital stepper motor, since the film is unsprocketed. The frame position is determined by sensing small index blocks at the lower edge of the film using a fibre-optics light guide and a photodiode.

The microform scanner contains three units. The first is a 35 mm. full frame digitally controlled camera/scanner which can read light through the film, or alternatively record computer-generated images. The second unit contains a 16 mm. Bolex camera for making computer-generated black and white movies and a modified 16 mm. film editor for scanning 16 mm. film of all types. The third unit is a microfiche transport mechanism for scanning and producing a single microfiche in the 72 image COSATI format. For the three different units the C.R.T. raster is adjusted optically to fit the particular frame size.

A fourth type of scanner is built around a microscope with a digitally controlled automatic stage. Positional accuracies are on the order of $\pm$ 2 microns, and the maximum slide area coverage is 1.2 inches x 1.2 inches. Variable reduction is available from a four objective rotating turret. Full visual observation is available to an operator.

4.1.11.2 Monitors

The monitors consist of 21 inch cathode ray tubes controlled in a manner similar to the scanner C.R.T.'s; viz., digital position counters control the spot location through accurate, high-speed digital-to-analog converters. The monitor counters are digitally controlled directly from the S-M-V Controller via an incremental communications scheme; essentially the only commands issued by the S-M-V Controller for the monitors are increment the counters, decrement the counters, reset the counters, and reset the parameters. Therefore, any spot movement possible on a scanner C.R.T. can be accomplished on the monitor C.R.T. The video input for the C.R.T. grid is also synchronized by the S-M-V controller.

Included with the monitors for communications to a central processing system are a selectric typewriter, microtape input/output tape drives, and a light pen for cursor control.

4.1.11.3 Video Switching Matrix

The video switching matrix is a mechanical cross bar matrix. Therefore, the switching speed will be in the order of 100 milliseconds or less. In this routing switch any source can be switched to from one to three different destinations simultaneously. In addition, switching provisions are also included to mix any two video sources to provide a composite signal to the selected destinations.

4.1.11.4 Character Generator

The Character Generator is designed to accept up to 512 ASCII characters into its 4096 bit memory. A 99 dot matrix, 9 dots wide by 11 dots high, is used to develop each character into the appropriate video levels. The maximum TV screen display is 16 horizontal rows of 32 characters or spaces each. Alternatively 132 characters/line printout can be generated on the Videograph printer. A special cursor is also available along with eight commands for controlling it.

4.1.11.5 Videograph Printer

The Videograph Printer can print on demand at a rate of 0.8 seconds per 8-1/2 x 11 inch sheet. Horizontal resolution is 128 lines per inch and vertical resolution matches the high resolution of the 1536 line slow CCTV cameras. Gray scale resolution is limited to four shades. The paper used is inexpensive zinc-oxide coated stock.

4.1.11.6 1536 F/S Cameras

The 1536 F/S cameras are vidicon camera units which can be remotely selected to operate either in fast scan mode (15 frames per second) or slow scan mode (1.25 frames per second). The format of either mode is 1536 lines per frame done in a sequential (non-interlace) scan. The aspect ratio is variable, but it is set for a nominal 8-1/2 x 11 aspect ratio. The camera bandwidth is limited to 9.5 Mhz for fast scan and 1.4 Mhz for slow scan.

4.1.11.7 Remote Video Consoles

Each remote console is a self-contained unit with two video monitors and the necessary equipment for communicating with a digital computer. The video monitors consist of a 17 inch 1536 lines per frame slow (1.25 frames per second) monitor with a P-26 phosphor and a 17 inch 1536 lines per frame fast (15 frames per second) monitor with a VC-4 phosphor. Each monitor matches characteristics of the associated camera.

Of the six remote consoles, three can be provided with high resolution television camera input.

4.1.11.8 525 Line T.V. Cameras and Monitors

The 525 T.V. Cameras and Monitors are conventional television units; namely, 525 lines per frame, 30 frames per second interlaced (60 fields per second). These units provide for relatively low cost reduced resolution, which is sufficient for many message routing and simple acquisition and display purposes.

4.1.11.9 HARDWARE STATUS REPORT

Percentage Complete

Processor/Unit: Scanner		0	10	20	30	40	50	60	70	80	90
Simulation											
Processing Hardware											
Control Sequences											
Estimated Number of Statements:											
Processing Hardware											
System Design	100%	■	■	■	■	■	■	■	■	■	■
Logical Design	90%	■	■	■	■	■	■	■	■	■	
Layout	90%	■	■	■	■	■	■	■	■	■	
Wiring	90%	■	■	■	■	■	■	■	■	■	
Checkout	40%	■	■	■	■						
Estimated Number of Cards:[1]	55										
Control[2]											
High Level Flowcharts											
Control Point Flowcharts											
Logical Design											
Layout											
Wiring											
Checkout											
Estimated Number of Control Points:											

Notes:

1. Digital-to-analog converters and other special function cards.
2. Subsumed to S-M-V Controller.

4.1.11.10 HARDWARE STATUS REPORT

Percentage Complete

	0	10	20	30	40	50	60	70	80	90	100
Processor/Unit: **Monitor**											
Simulation											
Processing Hardware											
Control Sequences											
Estimated Number of Statements:											
Processing Hardware [1]											
System Design 100%	■	■	■	■	■	■	■	■	■	■	
Logical Design 100%	■	■	■	■	■	■	■	■	■	■	
Layout 100%	■	■	■	■	■	■	■	■	■	■	
Wiring 100%	■	■	■	■	■	■	■	■	■	■	
Checkout 60%	■	■	■	■	■	■					
Estimated Number of Cards: 90											
Control [2]											
High Level Flowcharts											
Control Point Flowcharts											
Logical Design											
Layout											
Wiring											
Checkout											
Estimated Number of Control Points:											

Notes:

1. Indicator panels associated with the display of TP registers is not included in this estimate.
2. Control is sufficiently simple so that it has been subsumed to the processing hardware.

4.1.12 Intermachine Link

4.1.12.1 Function

An Intermachine Link provides direct coupling between the PDP-8/338 Computer Graphics System in the Department of Computer Science and a processor port of the Illiac III Exchange Net. The link provides two 50-bit data registers at the Illiac III end (one for receiving data, one for transmitting), full parity checking and timing signals to effect the information exchange. Four PDP-8 words are assembled to form one 46-bit word (augmented by four parity bits) in approximately 15 microseconds.

Included in the link is a teletype which may be used as a remote console typewriter to the PDP-8/338.

An independent link exists between the Department's PDP-8 and the Computation Center IBM 360/75 wherein these two machines can communicate via a graphics partition in the service computer. By extension then the Illiac III - PDP8/338 Intermachine Link allows exchange of data with the IBM 360/75 system.

4.1.12.2 HARDWARE STATUS REPORT

Percentage Complete

0 10 20 30 40 50 60 70 80 90 100

Name of Unit: Intermachine Link

Application

Processing Hardware

Control Sequences

Estimated Number of Statements:

Peripheral Hardware

System Design 95%

Logical Design 95%

Layout 85%

Wiring 85%

Checkout 85%

Estimated Number of Cards: 140

Control

High Level Flowcharts not used

Control Point Flowcharts not used

Logical Design 95%

Layout 85%

Wiring 85%

Checkout 85%

Estimated Number of Control Points: not used

Date:

7/20/69

4.1.13 Low Speed Terminal Network

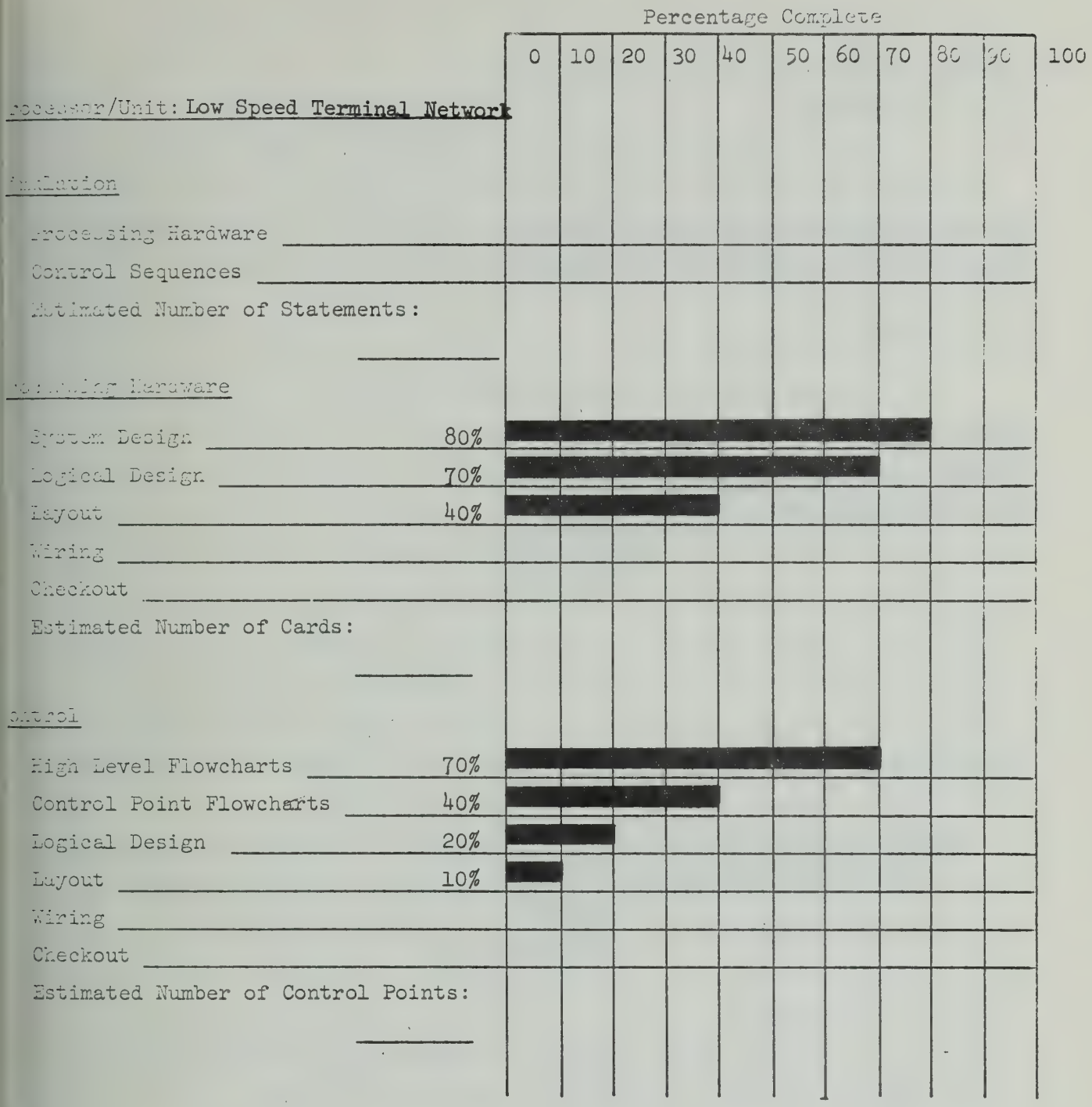
4.1.13.1 Function

This net is used to communicate with Illiac III via numerous remote consoles. Each remote console can have the following low data rate equipment from the available equipment pool: a teletypewriter, a Linc-type magnetic tape module, a machine control patch panel, and an analog instrument interface and a cursor control. Thus as many as five or more signal lines must be provided for each console to accommodate low speed equipment. The communication channels can be Bell Telephone lines (both analog and digital data-phone connections), direct wire links to local teletype consoles, or over multiple twisted-pair cables laid in conjunction with the Video Communications Net.

4.1.13.2 Design Features

The low speed terminal devices communicate with Illiac III through two Low Speed Buffers, each capable of handling 14 terminal devices. These buffers form in effect memory units directly accessible by a Taxicrinic Processor using standard operand addressing procedures.

4.1.13.3 HARDWARE STATUS REPORT



Plan:

4.1.14 Power Distribution

4.1.14.1 Function

The purpose of this system is to provide an effective means of controlling the power supplied to various subsystems of the Illiac III. The system allows individual sections of the machine to be de-energized for trouble-shooting and for initial calibration during checkout.

4.1.14.2 Design Features

The DC Power Distribution System comprises

1) the Primary Power Supplies

2) the Power Distribution Center, and finally

3) the Turn-on/Regulation Control.

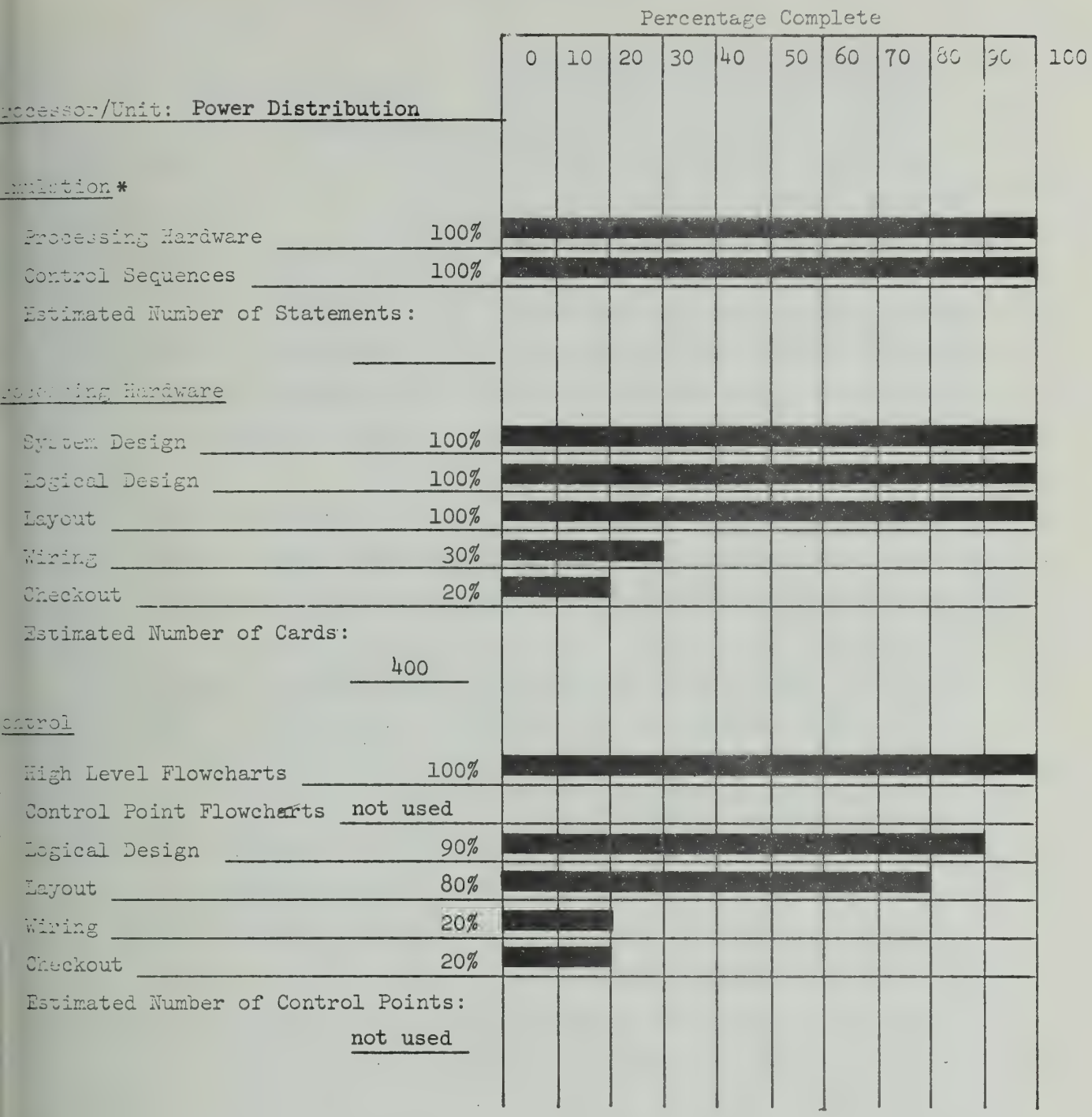
This latter control can be subdivided into four stages: turn-on of the control voltage supplies, turn-on of the primary voltage supplies to 50% nominal ratings, regulation of the primary supplies at full load and finally regulation and remote sensing of the DC power as distributed to the individual sections of the machine.

The AC Power Distribution System provides two 200 amp secondary panels and a tertiary 20 amp service with distribution to the requisite sections of the machine.

4.1.14.3 Documentation

A 150 page manual detailing the design and operation of the DC Power Turn-on/Regulation System is currently in draft form.

4.1.14.4 HARDWARE STATUS REPORT



Notes:

Simulation here is interpreted to mean analog circuit studies of the turn-on and regulation functions.

7/28/60

4.2. SOFTWARE DEVELOPMENTS

4.2.1 Operating System

4.2.1.1 Supervisor - Processor Interface Definition

One of the concerted goals of the Illiac III Computer System has been to formulate a simple but powerful Operating System. A key constituent of this strategy has been to study closely the Supervisor - Processor interface, with the hope that the software-hardware boundary might be bridged as harmoniously as possible. The report discussed below describes this work.

At the present the published description of the Taxicrinic Processors of Illiac III is deficient in three distinct areas. It is the purpose of a note by R. M. Lansford (now in draft form)[1] to supply most of this needed description.

a) The Taxicrinic Processors include sophisticated hardware to implment a two-level addressing scheme. The resultant software orientation and the operation of the paging hardware is explained.

b) A multi-level priority interrupt scheme is defined. In the note is described the interrupt classes and the appropriate interrupt action and attempt is made to isolate data which must be manipulated.

c) Specialized instructions must be provided to assist in the required manipulations. These instructions are defined and discussed.

---

1. Lansford, R. M., "Operating System of the Illiac III Computer: Supervisor-Processor Interface", Department of Computer Science Report (in progress).

4.2.1.2 Directory Structure

Two classical directory schemes are the binary-chop and sequential-link pointer* methods. The method to be described, which is essentially that of Hibbard[1], embodies many of the desirable features of these two schemes, while avoiding many of the disadvantages. This method or storage directory system will be referred to as the Binary-Chop Pointer method. The BCP method reduces to either the binary-chop or sequential pointer linked directory methods at either end of its functional spectrum.

The storage/directory method developed in the following paper, "Suggestions for Use of a Particular Directory Scheme" by D. Austin Henderson, Jr. and David E. Gold, Department of Computer Science Report No. 321, April 10, 1969, allows for flexibility in modification of a rapidly growing directory while maintaining a reasonable number of searches necessary to locate items whose keys are stored in the directory. A mathematical analysis shows the average number of searches to be of the same order of magnitude as for a binary-chop method of table look-up while the directory itself need not be reordered to accommodate new entries. The analysis is followed by a series of procedures and suggestions for procedures which should prove useful when employing this method.

---

*i.e. a directory in which a pointer in each entry indicates the next entry.

1. Hibbard, T.N., "Some Combinatorial Properties of Certain Trees with Application to Searching and Sorting", JACM6 (January 1962), 13-28.

4.2.1.3 Telecommunication Processing Package (TP^2)

A job control language has been defined consisting of approximately twenty directives covering the following areas:

1) Initialization and Access Privileges
2) File Manipulation
3) Program Assembly and Execution
4) Debugging

A task is the smallest unit operation which the computer may be requested to execute subject to a given deadline for completion. The command or instruction which causes the task to be executed is called a task directive. Accordingly task directives are commands or messages sent from the user's console to the computer to specify the next gross action the computer is to take.

The set of permissible directives defines a programming language -- one that is directly interpreted by the supervisor program. All other languages available to the computer system are considered subservient to this Task Directive Language. For this reason the latter language has been kept as simple and transparent as possible so as not to needlessly burden the user.

A description of the language can be found in File No. 782, "Task Directive Language for the Illiac III Computer" by Linda M. Katoh, December 9, 1968.

4.2.1.4 Image Processing Package (IP^2)

A number of graphical or pictorial description languages have been studied to determine desirable features of an image processing language, and to evaluate for each language its satisfaction of stated a priori criteria.[1] After a brief survey of some of the most representative of these languages, a new image processing language ICØN was defined.

---

1. Schwebel, John C., "Toward the Specification of a New Image Processing Language", Department of Computer Science File No. 788, February 6, 1969.

It is our contention that the evolving formal theory of cognitive systems provides a basis for defining an image processing language. Also implied here is that this language has a structure intrinsic to visual data processing and may transcend the Chomsky language framework. A paper is in preparation.

4.2.2 Translators

All work on translators has been stopped momentarily as all Research Assistants previously working in this area have been drafted for the war in Viet Nam.

4.2.2.1 IBAL Assembler

"The Illiac III Basic Assembler Language (IBAL)", Department of Computer Science Manual, March 1968 describes IBAL, the lowest level language used for Illiac III programs. With suitable constraints upon the naming of operands, each primitive operation in IBAL directly corresponds to one Illiac III machine instruction.

In comparison to other programming languages usually classified as "assembler languages", IBAL allows very general data declarations. In particular, declarations allow specifications of generalized tree-structured data items whose irreducible constituents are the smallest addressable basic elements of the machine. It is believed that this capability is essential to any programming language adequate for the translation of languages as complex as PL/1.

Work was resumed on Pass 1 of the IBAL translator, written in PL/I for the IBM 360. A state-transition matrix is used to process declarations. A structure table is set up for storage of declared structures (including single identifiers and arrays), with attributes and adjustment of node levels in the table according to declared levels and number of subscripts at higher levels.

Reserved words are recognized and those which are storage attributes are indicated in the appropriate places in the structure table. Cell sizes (B, W, H, D) are distinguished from node names by context. Terminal node attributes are evaluated (except for values and lengths of constants) in the structure table in terms of number of bytes or a pointer to a list to handle the LIKE attribute.

It is anticipated that the only further major additions that will have to be made to Pass 1 are suitable indication of alternate access structures and conditional format items.

4.2.2.2 PL/1

During the first quarter a set of nearly 450 productions for PL/1 was completed. In addition, the set of actions necessary to build tables during the Declaration pass was finished.

4.2.2.3 PAX II

In the course of design studies for the Pattern Articulation Unit (PAU), it proved useful to introduce a programming language PAX, initially considered as a simulator for the PAU. This language introduced, we believe, the first systematic use of connectivity information in image analysis. The PAX concepts were systematized and extended in a series of basic papers by Narasimhan (then at this laboratory). The PAX language, as PAX II, has recently been implemented for the IBM 360/75 by J. W. Snively, Jr. and E. B. Butt, formlery of the University of Maryland, and is used, for example, by Kirsch and Lipkin in their experimental studies of bio-medical image processing at the National Institute of Health. In addition PAX was taught this year as the language for picture preprocessing and feature extraction in a recent commercial course on Image Processing by Cybex Associates, Inc. PAX shows every promise of becoming the FORTRAN of image processing.

In an effort to provide a bridge between the present IBM 360 simulation and the PAU hardware execution of local feature extraction algorithms, the Snively-Butt version of PAX II was adapted to the Illinois installation. Report No. 314, "The PAX II Picture Processing System at the University of Illinois, March 1969, edited by R. T. Borovec describes the translator.

4.2.2.4 LEFT: Language for Editing and Formating Text

The problem of recognition and transcription of text, for example, the automated extraction of citation listings from technical serials, has elicited considerable interest. Central to all tasks of this character is the intermediate step of extracting a typographical description of the input text.

Our observation has been that much research on information retrieval has collapsed from sheer clerical burden -- the transcribing and editing of data for augmented catalog listings, etc. Accordingly it would appear more appropriate to master the textual transcription task first. This view has been consistently in mind in the design of the Illiac III computer system, and has dictated the choice of high resolution television equipment, the Videograph printer and our microfiche production and scanning equipment.

If an entering document is to be scanned and stripped of its typographical description, it must then be mapped into the analysis language (LEFT: Language for Editing and Formating of Text)[1]. That is, sufficient information is extracted from the input image that a typesetting machine could regenerate the document. The LEFT language embodies a complete distinction between the medium-independent structure of text and the purely typographical (or packaging) description of text.

Because of budgetary limitations, work on the LEFT translator was terminated early in the contract period and the definition of the LEFT language was summarized in Report No. 291.

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1. Flowerdew, Stanley J., "LEFT: A Language for Editing and Formating Text", Department of Computer Science Report No. 291, October 31, 1968.

4.3 PATTERN RECOGNITION THEORY

4.3.1 Graph Transformation Grammars

Work in this area is intended to provide a theoretical foundation for the study of graphical transformations applied to a set of objects interrelated by binary relations.

Given a large set of objects with complex interrelations, it may be possible to apply a transformation to a subset of objects -- and relations -- in order to simplify structure. The inherent hierarchial structure existing on the set may suffice to determine the simplification criteria.

For example, consider a Boolean algebra, X, of subsets of a set. The inherent structure is given by the binary operations "union" and "intersection". An example of a possibly desirable transformation is: $X_1R_1X_2$ and $X_2R_2X_3$ transforms to $(X_1 \cup X_2)R_2X_3$. A criterion for performing this transformation may be its reversibility, i.e., if:

$$(X_1 \cup X_2)R_2X_3 \text{ and } X_1R_1X_2 \longrightarrow X_2R_2X_3$$

The transformation given above allows us to form an expression by grouping two elements of the set into a composite element. Other transformations may correspond to general ways of forming expressions of operations, relations and elements of X.

We would like to be able to answer questions such as the following:

1) For which individual relations is a transformation possible for all x independent of other relations involved in the subgraph being transformed.

2) For which groups (e.g. pairs or triplets) of relations is the transformation always possible.

A report to be issued in August entitled, "Consistent Properties of Composite Formation Under a Binary Relation" by J.C.Schwebel and B.H.McCormick attempts to define properties of binary relations that will be useful in implying graph transformations. Properties of a general relational system between lattices are defined. Then a reduction of the set of possible consistent combinations of properties is carried out, followed by a construction procedure to obtain examples of all consistent combinations. This paper supersedes File No. 769.

A paper in progress enumerates and considers some specific graph transformations. An attempt is made to answer the first question above by showing which transformations can be implied by properties defined in the above report. Question 2 is approached by considering the partitions induced on a class of relations according to their behavior in a transformation.

It is our intention to apply the theoretical work in this area to image processing. The results so far are quite general and may have application to other areas requiring a classificatory or general composite analysis approach.

4.3.2 Game Model of Image Processing

In what sense can it be said that a given machine can recognize and describe pictures as well as a man? In what way is the machine demonstrated to be as clever as a given human observer?

One can envision matching machine and human image recognition abilities at interim stages in the recognition process. To do so implies that the human perceptual processes must be slowed down -- by selective information starvation -- so that the recognition algorithms can be better monitored. We can withhold from the observer spatial information -- allowing him to see only small "chips" of the total image, constrain his exposure time (image flashing), delete from the image given spatial frequencies (holographic filtering), compress gray and color scales, etc.

However, consider the following game (Figure 1): the player is presented an image projected onto a light-absorbing surface. He is then given a set of chips, of various sizes and weights (costs). The "game" is to place these chips upon critical nodal areas of the image in a manner to first achieve an adequate description of the image (the "aha" point) at the least aggregate cost in chips. Given a homogeneous class of images (aerial photographs, blood cells, machinery, etc.) it should be possible to train players: by recording the moves and strategy decisions of the experienced player, the novice can acquire the requisite techniques. And this training process in turn can be used to better codify the recognition strategies employed -- extending in greater detail the familiar scanning instructions, as previously developed for scanning fingerprints and bubble chamber film.

A feasibility study was undertaken this past contract year to probe the reality of this game model of image processing. Simple line drawings, cartoons and cytological smears were used as test scenes. For line drawings and cartoons the experience with the game soon lead to the concept of a name-independent parse of the scene (see Section 3.3 below). However, the original definition of the game for images rich in texture proved inadequate, and has forced us to formulate alternate definitions of texture. In general the game model approach to image processing would now appear to warrant serious and systematic investigation.

4.3.3 Analysis of Simple Line Drawings

Is it possible to decompose a visual scene into the constituent objects forming it, without requiring prior detailed knowledge of these objects? For the restricted but important case of scenes of juxtaposed 3-dimensional blocks, Guzman[1] has given a heuristic strategy: "[The program] does not need to know the "definitions" or descriptions of a pyramid, or pentagonal prism, in order to isolate these objects in a scene containing them, even in case they are partially occluded.[2] For more general scenes there are as yet no comparable image articulation strategies.

To view the question differently, consider simple line drawings -- such as the illustrations of a child's coloring book. Here we instinctively group together the heavily-outlined regions of these scenes to build composite structures, and continue this process to decompose the scene into its constituents. Hence, prior to the naming of the objects of the scene we can extract the lattice (i.e. the extension for scene description grammars of the description tree, or P-marker, of context-free languages) representing the decomposition of the scene into composite items. Of course these items may represent partially occluded objects, which can probably be filled in (revealed) only with the use of supplementary name-dependent information. (The classical case of implying the occluded table leg comes to mind.) But the critical observation is that a name-independent structural decomposition of the visual scene is normally possible -- even though we do not yet know how to mechanize the process. If we were to descend the evolutionary scale we might hypothesize that successive animals must survive with an ever smaller vocabulary of object names, and hence these animals need to rely increasingly upon a name-independent type of scene decomposition.

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1. Guzman, A., "Decompositon of a Visual Scene into Three Dimensional Bodies, AFIPS-Vol. 33, 1968.

2. ibid, p. 303.

An early attempt to mechanize this latter type of image articulation has been reported by John Schwebel[3]. In the strategy employed there, the irreducible regions of the image are presented as the nodes of a digraph, linked by inter-regional relationships of "near", "inside", "abuts", etc. A consistent procedure for clustering nodes (regions) together to form new composite nodes, and extending the relational links to these composites, is described.

This contract year the above name-independent "parsing" strategy has been further studied[4], with an eye to using similar digraph representations of the input scene, and like visual clues which are intrinsically name-independent. Strategies of this type will in the future require computer simulation, as the eye/brain is too easily beguiled in making faulty hand simulations which ignore consistent, but visually-abhorrent, scene decompositions.

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3. Schwebel, John C., "Use of Graph Transformations to Characterize an Image: An Illustrative Example", Department of Computer Science File No. 770, July 1968.

4. Schwebel, John C., McCormick, B.H., "Analysis of Simple Line Drawings", Department of Computer Science File No. 796, April 11, 1969.

4.4 BIBLIOGRAPHY

4.4.1 Publications

McCormick, B. H., "Advances in the Development of Image Processing Hardware", Image Processing in Biological Science, Ramsey, D.M. (Editor), University of California Press 1968.

Atkins, Daniel E., "Higher-Radix Division Using Estimates of the Divisor and Partial Remainders", IEEE Transactions on Electronic Computers, Vol. C-17, Number 10, October 1968.

Dunn, L.A., et.al., "Parametric Description of a Scan-Display System", AFIPS Conference Proceedings, Vol. 34, p. 187-206.

4.4.2 Papers Presented (Conferences)

Atkins, Daniel E., "Design of the Arithmetic Units of Illiac III: Use of Redundancy and Higher Radix Methods", Workshop on the Theory of Computer Arithmetic, Third Annual IEEE Computer Conference (Minneapolis), June 1969.

Borovec, Richard T., "A Report on the Use of Microprogramming for the Illiac III Image Processor", ACM Workshop on Microprogramming, Bedford, Massachusetts, October 6-9, 1968.

4.4.3 Outside Talks

McCormick, Bruce H., "Graph Grammars for Image Processing", Joint Meeting with the Society of Photo-Optical Instrumentation Engineers and the Pattern Recognition Society, Washington, D.C., August 25, 1968.

McCormick, Bruce H., "Seeing and Believing by Machines", Sixth Annual Allerton Conference on Circuit and System Theory, Allerton House, Monticello, Illinois, October 2, 1968.

4.4.4 Reports and File Numbers Issued

Report	
Report No. 275	Borovec, R.T., "The Logical Design of a Class of Limited Carry-Borrow Propagation Adders", August 1, 1968.
Report No. 285	Koo, Ping L., Borovec, R.T., "The Pattern Articulation Unit of Illiac III Simulation: Part I-Iterative Array Transfer Memory-BOOLE Control", September 20, 1968.
Report No. 290	Koo, Ping L., Atkins, Daniel E., "Arithmetic Unit of Illiac III: Simulation and Logical Design-Part II", October 28, 1968.
Report No. 291	Flowerdew, S.J., "LEFT: A Language for Editing and Formating Text", October 30, 1968.
Report No. 308	Dunn, L.A., et.al., "Parametric Description of a Scan-Display System", February 5, 1969.
Report No. 314	Borovec, R.T., "The PAX II Picture Processing System at the University of Illinois Programming Manual", March 18, 1969.
Report No. 320	Divilbiss, J.L., "Illiac III Scanner Analog Circuits", April 10, 1969
Report No. 321	Gold, D.E., Henderson, J.A., "Suggestions for Use of a Particular Directory Scheme", April 10, 1969.
Report No. 333	Atkins, D.E., "Design of the Arithmetic Units of Illiac III: Use of Redundancy and Higher Radix Methods", May 1969.
Report No. 338	Borovec, R.T., Watson, W.J., "The Pattern Articulation Unit of Illiac III: Hardware Implementation of the Homogeneous Instruction "BOOLE", June 20, 1969.
Report No. 341	Nordmann, B.J., "Illiac III Computer System Manual - Taxicrinic Processor (TP)", Volume 1, July 1969.

File Number

File No. 769	Schwebel, J.C., McCormick, B.H., "Properties of a Discrete Space Preserved by Image Processing Relations", July 18, 1968.
File No. 770	Schwebel, J.C., "Use of Graph Transformations to Characterize an Image: An Illustrative Example", July 18, 1968.
File No. 771	Engle, J.T., "PL/1 Declaration Pass I - Structure", June 28, 1968.
File No. 773	Krabbe, S.P., "Specifications for a 9" False Floor for DCL 223 That Overlaps Existing False Floor in DCL 280", August 7, 1968.
File No. 776	Borovec, R.T., "The Pattern Articulation Unit of Illiac III: Display System: Design and Implementation", September 30, 1968.
File No. 780	Flowerdew, S.J., "Automatic Karyotyping: A Statement of the Problem and Summary of Image Processing Procedures", November 6, 1968.
File No. 782	Katoh, L.M., "Task Directive Language for the Illiac III Computer", December 9, 1968.
File No. 788	Schwebel, J.C., "Toward the Specification of a New Image Processing Language", February 6, 1969.
File No. 790	Krabbe, S.P., "A Discussion of Illiac III Processor-Unit Communication via the Exchange Net", March 4, 1969.
File No. 794	Dunn, L.A., et.al., "Programmed Aids for the Scan-Display System of Illiac III" (to be used with Report No. 308), March 14, 1969.
File No. 796	Schwebel, J.C., McCormick, B.H., "Analysis of Simple Line Drawings", April 11, 1969.
File No. 797	McCormick, B.H., "Illiac III Bibliography, Condensed Listing", April 30, 1969.

File Number(550 Series)

File No. 550-116	Krabbe, S.P., "Supplemental Specifications for Wire Wrap Wiring of Sections 1 and 3 (PAU) of the Illiac III Computer System, August 13, 1968.
File No. 550-117	Serio, F.P., Pelg, E., "Procurement and Design Specifications for Printed Wiring Boards", September 23, 1968.
File No. 550-118	Krabbe, S.P., "Specifications for Termi-Point Wiring of Section 6 (Taxicrinic Processing) of the Illiac III", November 29, 1968.
File No. 550-119	Krabbe, S.P., "Specifications for Wire Wrap of Section 13 (Exchange Net)", November 6, 1968.
File No. 550-120	Krabbe, S.P., "Specifiations for a 9" False Floor for DCL 223 That Overlaps the Existing False Floor in DCL 280", November 5, 1968.
File No. 550-121	Krabbe, S.P., "Specifications for Wire Wrap of Section 14", November 5, 1968.
File No. 550-123	Krabbe, S.P., "Specifications for the Mechanical Termination of Twisted Pair Transmission Line Z_o = 95 ohms $\pm$ 5 ohms With Burndy Contacts in the Illiac III Exchange Net", January 28, 1969.
File No. 550-124	Krabbe, S.P., "Specifiations for Power Wiring of Section 7 (Arithmetic Unit) of Illiac III Computer System", February 5, 1969.
File No. 550-125	Krabbe, S.P., "Specifications for Termi-Point Wiring of Section 7 (Arithmetic Unit) of Illiac III Computer System", February 18, 1969.
File No. 550-126	Borovec, R.T., "Specifications for Wire-Wrap Wiring of Integrated Circuit Board 1018-299-00", March 13, 1969.
File No. 550-127	Krabbe, S.P., "Specifications for Mechanical Termination of Coaxial Cables (RG-195/U Used in the Illiac III System", March 11, 1969.
File No. 550-128	Lewis, G.T., "Specifiations for Termi-Point Wiring of Section 32B (Descrete Beam Motion Logic) of the Illiac III Computer System", April 16, 1969.

4.5. ILLIAC III STAFF

Senior Staff

Dr. James L. Divilbiss - Principal Research Engineer
Dr. Robert M. Lansford - Research Associate
Professor Bruce H. McCormick - Principal Investigator
Professor Sylvian R. Ray
Professor K. C. Smith - Consultant

Professional Staff

Robert C. Amendola
Richard T. Borovec
Lawrence A. Dunn
Mrs. Linda M. Katoh
Ronald G. Martin

Electronic Engineering Assistants

David L. Foster
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Edmund Pelg
Frank P. Serio
Joseph V. Wenta

Electronic Technician II

John L. Fileccia
Robert G. Thomson

Electronic Technician I

Eugene E. Althaus
George T. Lewis
William A. Miller
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Engineers

*Daniel E. Atkins
*Sergio Franco
*Lakshmi Goyal
*Richard P. Harms
*Bernard J. Nordmann
*Val G. Tareski

Programmers

Miss Mary Ann Hagen
*John C. Schwebel

Drafting

Ronald C. Morrison
Stanislavs Zundo

Secretarial

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---

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REPORT SUMMARY

Several major problem areas were discussed in the QPR for Oct.-Dec. 1968. As indicated in the QPR for Jan.-March 1969, actions to solve these problems have been initiated. The contract with Fairchild to produce the semi-conductor memories has been signed and progress to date is according to schedule. A contract has been signed with Texas Instruments to provide the semi-conductor devices for the ILLIAC IV. Obtaining artwork for the production of the 12 layer CU boards remains a serious problem. Progress has been made in using the Design Automation programs to route the CU boards. However, Burroughs must increase the number of boards routed each week to insure that the CU schedule is met. The route program is being modified to reduce the computer time required to automatically route boards.

A PDP-9 computer has been ordered to attach to the PE exerciser to provide the ability to automatically diagnose errors in the PE and CU boards during manufacturing and final operation at the University. The PDP-9 will be delivered to the University in August for software development. In October the PDP-9 will be shipped to Burroughs to be interfaced with the PEX.

The monthly project review at Burroughs has proven to be very worthwhile, and the reviews will be continued. This quarter a new version of the machine characteristics and program manual has been drafted by Burroughs. This manual contains instruction timing information that was lacking in the original version. The published document will be available next quarter. In addition, the assembly language manual and simulator manual have become available. A user's group (FOURUM) was established for intercommunication and exchange of computer programs and documents for ILLIAC IV. A monthly newsletter will be sent to each participant.

As a result of the many changes in the project, Burroughs is now in the process of rescheduling their portion of the ILLIAC IV project. The new schedule will be available in August and some slippage is anticipated. The University is in the process of renegotiating the Burroughs subcontract to reflect the changes in cost, schedule, and performance. Every effort will be made to identify milestones which will permit the University and Burroughs to begin negotiation on a fixed ceiling contract.

A project has been initiated to permit Burroughs ALGOL to be compiled and executed on CDC 6000 series machines. In particular, this provides 6000 series owners with the ability to simulate ILLIAC IV programs. Many potential ILLIAC IV users are currently users of the CDC 6000 series machines. To provide archival storage, an evaluation of a 10^{12} bit storage device was initiated.

A proposal to create a Center for Advanced Computation based on the ILLIAC IV computer has been presented to the Board of Trustees, University of Illinois. The main purpose of this Center is to provide an environment for the interdisciplinary use of the ILLIAC IV computer. Professor D. L. Slotnick is proposed Director of the Center. The Center staff will be primarily ILLIAC IV project personnel with additional staff being hired as the machine operation begins. It is anticipated that a new building will be constructed to house the personnel and the ILLIAC IV computer. Additional details will be presented in the next Quarterly Progress Report.

5.1 Logic Debugging and Diagnostics

5.1.1 PE Logic Simulation and Debugging

Verification of the corrected PE design and debugging of Burroughs' functional test routines were the main uses of the PE Logic Simulator, during this quarter. The power of parallelism was fully demonstrated. Because up to 47 cases are simulated in parallel, the execution of the simulator took only a fraction of time required by the PEXTAP assembler. The Equation Generator Program was used in updating equations of the control logic and generating inputs to the control logic test generator programs.

By the end of this quarter, Burroughs had updated the PE design with the University's recommendations and other corrections. A new simulator will be generated from the new wire list file in the next quarter.

5.1.2 CU Logic Simulator System

5.1.2.1 CU Card Simulator

Several improvements and corrections of the CU Card Simulator Generator system have been made using corrected net lists. A control program has been developed in order to execute various programs of the system automatically. It will be incorporated into the system soon with the history generation program.

5.1.2.2 TESLA

Debugging of the TESLA compiler has been completed. With the exception of the LOOP and INOUT verbs, the full syntax of the language has been implemented. Some minor modifications to the syntax have been made as a result of "living with" the language during the compiler writing and debugging phases. When an attempt was made to apply TESLA to PE card simulations, several differences between CU and PE signal naming rules

were discovered. Since signal names are recognized by their structure (e.g., 10 characters, presence of dashes, etc.), a few minor changes were necessary for TESLA to produce PE card simulation control files. The ILLIAC IV Translator Writing System has continued to be of invaluable assistance. It was felt that TWS assisted even during debugging. Error isolation was much easier because of the sharp separation between syntax and the various semantic routines.

5.1.2.3 Assembled Code Translator (ACT III)

The purpose of this program is to translate from the PEXTAP object code into a suitable input file for the CU Card Simulator and also to produce the printer control file for the simulator. In essence, ACT III is a simulator of the PEX and the CU Card Adapter. Part of this program is derived from the ACT program written for the PE simulator.

The program first loads the expected response, mask data, and microsequence registers of the PEX. It then decodes the EIC (Exerciser Instruction Command) into a time sequence of commands. At any given clock pulse, it compares the test patterns (microsequences) with the corresponding ones at the previous clock pulse and passes the changes, if any, along with the particular simulator input array subscript, input verb, storage element state, and various other commands to the simulator input file. The printer control file is formed using the expected response, the output array subscripts corresponding to the group of output pins of the simulator, and the various other printer commands.

The program uses the adapter card data and the simulator data to establish a correspondence between the PEX output signals and the simulator input subscripts. (Similarly, the correspondence between the output pins and the output array subscripts of the simulator is established Due to the lack of information of these data, the program had to be run onl with simple examples. It appears that the PEXTAP files will have to be slightly modified to take into account the coordination of the input and output select bits required for the CU card tester. It is proposed to extend the ACT III program to provide output in a parallel form to the simulator.

5.1.3 PE Diagnostics

5.1.3.1 Path Tests

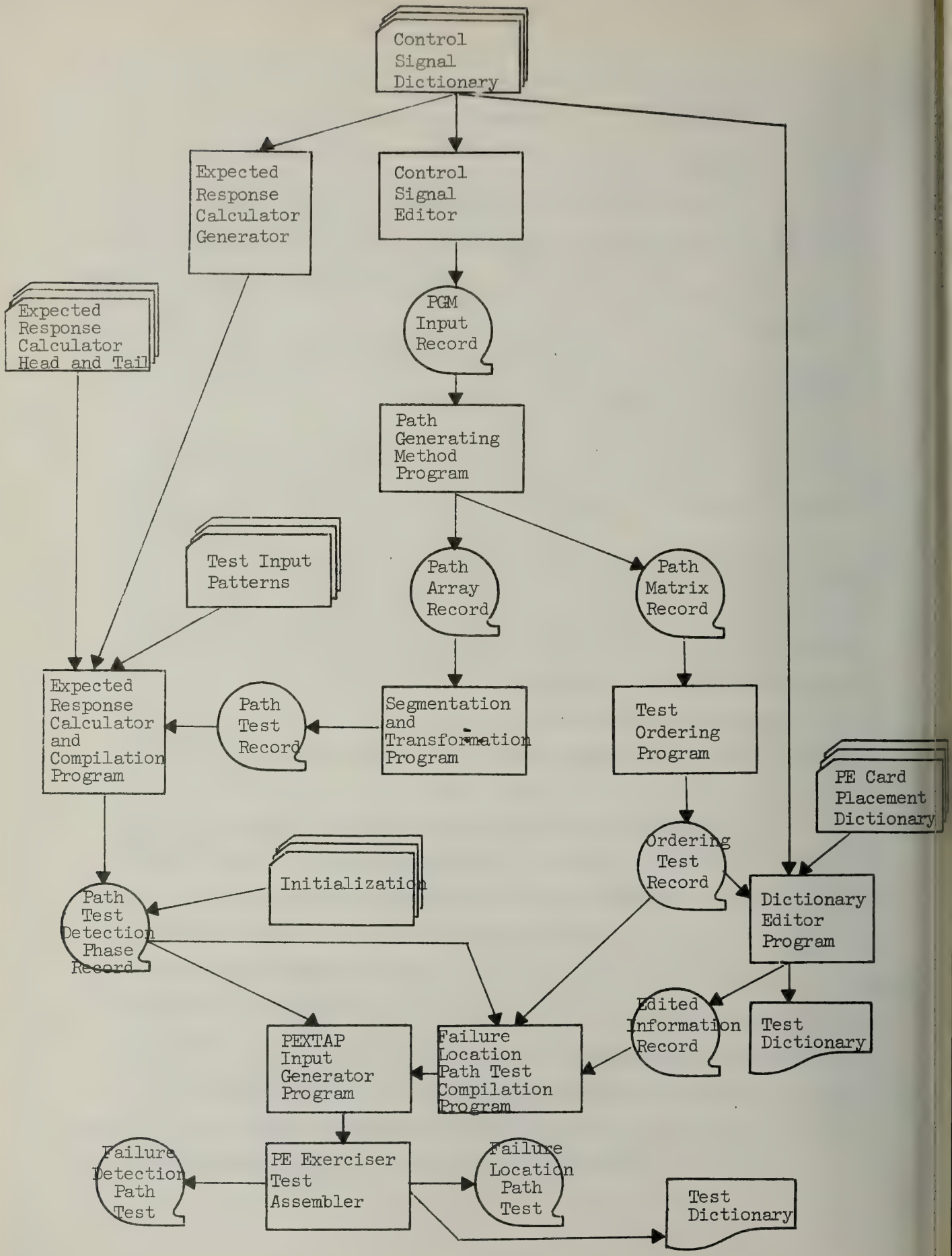
The path test generator system was completed in this period. Two major path tests have been generated: the failure detection path test and the failure location path test. The failure detection path test will be used for checking out the PE with the PE Exerciser to determine if there are component and/or wiring failures on the major data paths. If a failure is detected, then the failure location path test is executed to locate the failure within a small area of the machine.

An earlier version of the failure detection path test was released at the beginning of this period, and the first version of error location path test was created with the preliminary test dictionary.

The path test generator system requires two major inputs, the control signal dictionary and the PE card placement dictionary, both of which are written in fixed format. The control signal dictionary is translated into an arc description of the major data paths for the PGM (Path Generating Method) program.

The PGM finds a minimal set of test paths on the system described in a directed graph and creates a set of test paths and a path matrix.

The segmentation and transformation program reduces the dummy nodes which have been temporarily inserted in the graph model of the PE data flow and segments the test paths at appropriate points (for example, if a test path passes through a same node twice, it should be segmented at a storage element in the loop). The expected response calculator and compilation program (which is essentially a functional simulator) is generated from the control signal dictionary with additional routines. This produces the input file of the failure detection path test for the PEXTAP (PE Exerciser Test Assembly Program) except the microsequences which must be translated into the input format by the PEXTAP Input Generator Program. Each path test string follows a fixed initialization micro-step



PE Off-line Path Test Generator System

to clear registers. The expected responses are verified twice by the logic simulator for the output file of the expected response calculator and the input file to the PE exerciser. The failure detection path test provides no information about the failure location.

The TOP (Test Ordering Program) generates the path test sequence as the fail-and-branch tree structure and prepares necessary information to identify the failures.

The dictionary editor program edits the test dictionary based on the PE card placement dictionary and the output of the TOP to give details, such as the physical card position, card type, wiring between cards, etc., associated with the terminating point.

The contents of the dictionary are also merged to the tree-structure path test, and a path is picked from the failure detection path test string and translated into the PEXTAP input format by the failure location path test compilation program. Information to locate failures also appears in the document as a PEXTAP output.

The maintenance and modification of the path test will be continued to keep up with the design changes of the prototype and production PE's. A few additional programs will be required for running the path tests with the PE exerciser hooked to the supervising computer.

5.1.3.2 Combinational Tests

A reduced set of test patterns has been generated for the Carry Propagate Adder based on the new design.

5.1.3.3 Control Logic Tests

A set of Boolean equations of PE control signals was derived from the control logic wire list. This set of equations contains a significant amount of redundancy. During this period, a program was written to reduce redundant terms and apply DeMorgen's theorem to the equations. These simplified Boolean equations are transformed into a graph and then fed into PGM program. From the output of PGM, a minimal set

of tests to diagnose the control logic can be derived. The purpose for this transformation was also written in this period. The first section of the program is to find illegal expressions in the Boolean expressions; the second section is to rearrange signal names in order to fit PGM; the third is to expand the Boolean expressions inside the innermost set of parentheses into graph form and then to expand toward the outside set of parentheses. In the present version, about 100 Boolean equations are associated with the control logic, and they are transformed into a graph which contains about 1,800 card images. A minor modification will be made in order to increase the power of the program.

5.1.4 PEX Computer and Supervisor System

A modification of the PE Exerciser from the original manually-controlled papertape-based equipment to a high-speed flexible computer-controlled system had been proposed earlier by the University. The Burroughs programming group had joined in calling for the adding of additional control and computational capabilities to the PEX. However, in this quarter, the Burroughs Project management decided to terminate their efforts along this line. The University diagnostics group started designing both hardware and software for the control computer.

The PEX as currently implemented, although soundly designed, simply lacks the speed and flexibility necessary to insure rapid debugging of PE's. After ILLIAC IV was operational, this deficiency could have caused a higher than necessary MTTR, requiring the maintenance of additional spares and perhaps reducing the availability of ILLIAC IV. While ILLIAC IV is being produced, the deficiency would have been critical. It would have been difficult to meet current prototype debugging and production check-out schedules with an unaugmented PEX. Therefore, it was proposed that a small computer of the 16-18 bit word length class be interfaced to the PEX to be used as a dedicated PEX controller. Various candidate computer systems were evaluated and a Digital Equipment Corporation PDP-9/L computer was selected as offering the most flexible, lowest cost system which could be obtained within the necessary time frame.

Improvements to be wrought by this addition include the following:

(1) More rapid input to the PEX. As currently implemented, the PEX has only paper tape and cards as input media. The computer system includes magnetic tape; this will result in an order of magnitude increase in input rate.

(2) Greater control by technician. With the computer-controlled system, the technician will have control over the consequences of a test failure (e.g., print and continue, halt, branch, etc.). Further, the technician will be able to control repeated execution of the tests.

(3) Assembly and running of arbitrary groups of arbitrary tests. This will permit the technician to create his own group of tests, when and as needed, rather than be dependent only on pre-assembled routines.

(4) Greater information to technician. As currently implemented, the PEX only displays the differences between what was expected and what was obtained. With the computer system, the actual and expected results will both be printed, and the technician will be able to display or modify the contents of any register in the PE.

(5) Analysis of test results and dynamic modification and adaptation of tests. With the proposed system, the full 64-bit result will be sent to the computer for analysis. Interactive, on-line modification of tests in response to previous results can be implemented, permitting rapid isolation of the failure area and order-of-magnitude faster fault diagnosis.

(6) Assembly of PEXTAP programs. The assembler for compiling programs written in the PEX assembly language, PEXTAP, must be run on a B5500 or B6500. This function can ultimately be transferred to the PEX control computer, lessening the dependence of the diagnostic and maintenance group on outside facilities, particularly facilities being used to control ILLIAC IV.

A PEX Supervisor language had already been designed by Burroughs, with some modifications and improvements suggested by the Diagnostics Group at the University. Major elements of the supervisor have been analyzed and designed, and coding should be easily accomplished once the machine has arrived. While the language was being designed, close liaison was maintained with the technicians who will actually do the debugging of the

PE's. The proposed language has their enthusiastic support as an instrument which, when implemented through the desired computer system, will significantly increase their productivity.

5.1.5 CU Diagnostics

5.1.5.1 Bad Board Simulator

The specification of Bad Board (Card) Simulator has been defined and possible failure modes have been specified.

(1) Failure Modes: Failure modes were defined for each package based on the logic diagrams of DIL packages supplied by Burroughs. For the purpose of reducing the number of failure modes several considerations were made.

(a) Indistinguishable failure: Within a package some failures are indistinguishable: for example, for an AND gate input and the output stuck at zero, failures are indistinguishable. Also, if a logical element has only one fan-out, the failures of its output and of the input to the next element are indistinguishable. A class of all indistinguishable failures is represented by an equivalent representative failure.

(b) Undetectable failure: The logic equations in the Bad Board Simulator express all possible failures in a package. But all logic elements are not always used. Therefore, if a failure of an unused element is applied to Bad Board Simulator, a test for this failure cannot be found. The other case is that of an input pin connected to a constant voltage. This is equivalent to a stuck failure.

(c) Primary and Secondary failures: Some distinguishable and different failures can be detected by a test which detects other failures. Therefore, those failures are called secondary failures and these primary failures. Though both failures are described in the logic equations, the generation of test patterns will work only on primary failures at first. Thus, the number of failure modes to be considered is reduced. The average number of failure modes per package is about 15 to 20, and a typical CU Board contains about 1500 failure modes.

(2) Bad Board Simulator Generator: All parts of the CU card Simulator Generator System except the simulator body generation program can be applied to the Bad Board Simulator Generator. This program has been coded and is now being debugged. Some features of Bad Board Simulator are: (a) The Bad Board Simulator will accept any possible single logic failure. It will also simulate correct logic. (b) Since the program has the capability of parallel simulation, 47 different input patterns are simulated in parallel.

5.1.5.2 CU Card Test Generator

The final organization of the CU card test generator system has been investigated, during this period. The system will be composed of a Failure Mode Collector, Pattern Generator, and Test Controller into which the Good/Bad Card Simulator is to be incorporated, as well as other functions formerly implemented by other blocks. The coding and debugging of the Failure Mode Collector and the Pattern Generator have been completed.

At the present time, some parts of the Test Controller have been coded and debugged and it is expected that a first version of the system will soon be operational.

5.1.5.3 On-line Diagnostics

Preliminary drafts of Diagnostics Specifications have been received from Burroughs. The review of techniques and assignment of task items as well as rescheduling of implementation of the programs will occur in the middle of July.

5.2 Design Automation

Work has continued, at the University, on the Post-Processor Program. Small additions have been made to the software while the program is being tested in a production environment. Burroughs has been using the program, together with electrical draftsmen, to check PC artwork before release.

The plan to do Burroughs' DA computer runs on the University's B5500 is paying off. The early estimates for the computer time required have proven to be quite low. All PC artwork for the CU is being routed on our B5500.

5.3 Operating System

During this quarter, the design for the operating system was reviewed and modified. The system design philosophy remains oriented toward a highly distributed system that will be operationally efficient in a multiprogramming environment. The key to distributing control among the system elements is the use of buffer files. With these files one program can send a message to another, or several programs can contribute to the message. The buffer file mechanism was implemented on the B5500 during this quarter.

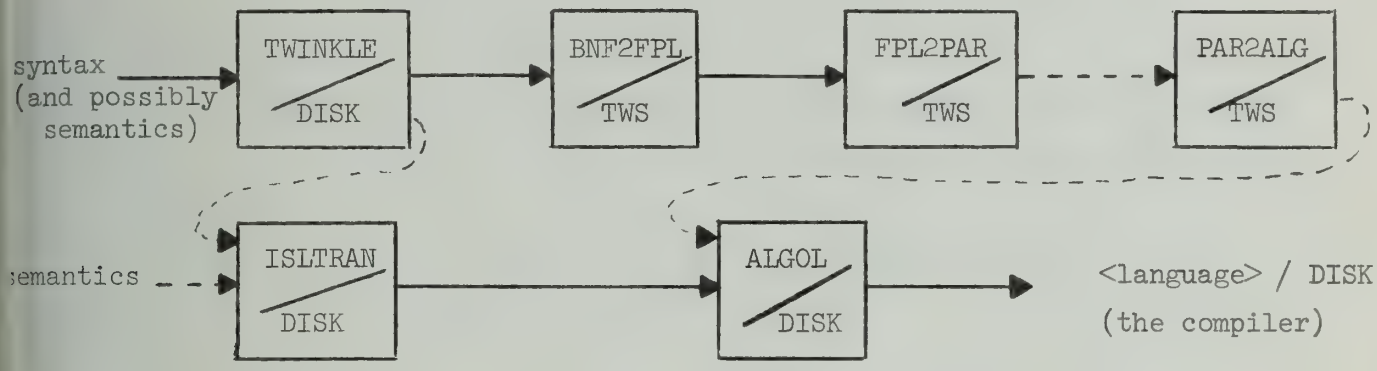
Another major effort of the quarter was the commencement of meetings between the operating system programmers and those working on Tranquil. The meetings have proved to be exceptionally fruitful and are occurring at a time when both segments of the projects are still malleable.

With minor deviations, the schedule given in the preceding QPR has been maintained. This schedule is still being followed.

5.4 Translator Writing System

A new method of making a Floyd production parser was conceived. This method uses a "Floyd production" procedure which is called once for each Floyd production with different parameters for each call. These parameters are switch indices and operands corresponding roughly to the individual parser pseudo-orders and their operands. The code for each pseudo-instruction is incorporated as a subcase in the Floyd production procedure, each executed according to the values of the switch indices. This method will result in one access of the parsing table per Floyd production instead of one access for each operator or operand. The result should be a faster parser since there will be less overlay and less calculation of parsing table indices. The direct (ALGOL) implementation will be blocked according to the logic structure of the Floyd production language and hence to the advantage of the B5500 rather than the artificial blocking now used. It will also be much smaller than the previous version. The result of both of the above differences is expected to be a direct implementation which is both fast enough and small enough to be practical for even medium sized languages.

The new version will also implement the first version of TWINKLE as a syntax metalanguage with possible automatic linking to ISLTRAN and to the ALGOL compiler. The sequence of programs executed are indicated by the following directed graph where "——▶" indicates a necessary automatic step and "- - -▶" indicates an optional automatic step.



The compilers generated are suffixed "DISK" and are used as in the following example for the language "DUMMY":

```
? USER = ME

? COMPILE  MY/OBJCODE  WITH DUMMY  LIBRARY
                                    (or syntax)

? DATA CARD
    [   source code
? END
```

During this quarter, a complete revision of the overall structure of the TWS system was made. The reasons for such revision were threefold:

(1) The TWINKLE compiler is ready to be integrated into the system. This asked for considerable modifications in the ISL translator and syntax preprocessor.

(2) As a result of the tests described in the last report which indicated the inefficiency of the directly coded (or executable) PARSER, a completely new way of generating such parsers was devised, as outlined above. These modifications required a complete rewriting of the parser-instructions generator and the converter from parser-instructions to ALGOL code.

(3) Since it is expected that the system will be in its final form by the end of the summer, several features, long planned but never implemented, are now being added. Among these are: (a) the ability to submit the syntax and semantics of a language together in one file and have the system end up with a compiler for that language, after automatically executing six separate programs; and (b) the provision to accept n-pass compilers ($n \geq 1$) in a completely automatic way.

The final structure of the system is now settled, and work in the modifications described is well advanced.

5.5 Compilers and Translators

5.5.1 TRANQUIL

Work on the pass 2 semantics ALGOL coding and debugging continued during this quarter.

A basic subset of the defined TRANQUIL language (which will hopefully be implemented by October 1, 1969) has been identified, and plans and schedules were made for completing this subset. Some of the features not included in this basic subset are: array operators, multidimensional sets, procedures, I/O, simultaneous control using general sets (GENSETS) and 32-bit arithmetic.

Procedures and a macro facility for TRANQUIL have been specified. Implementation of procedures for TRANQUIL has been initiated at the pass 1 level.

The TRANQUIL compiler group has attempted to improve communications both with prospective users of TRANQUIL and with the operating system designers and implementors. Discussions with users have led to specifications for compiler diagnostics and debugging aids. The TRANQUIL-operating system interface requirements have been investigated, particularly the areas of storage allocation, I/O, and dynamic overlay of data and code. Work in these areas will continue.

Considerable time has been devoted this quarter to the problems of work load analysis, scheduling, and staffing for implementation and maintenance of the compiler beyond the basic subset.

5.5.2 GLYPNIR

GLYPNIR is now fully implemented as described in DCS Report 332, except for certain literals and the ABS, SIGN, and ENTIER functions. Further development of the language will be delayed pending user evaluation of the current package.

5.6 Assembler

No work was done on the ILLIAC IV assembler during the last quarter due to commitments of personnel to the DA and Diagnostics areas of the project. It is expected that this investment will pay off by reducing the execution time of some of the DA/Diagnostics programs and thereby free time for debugging the operating system.

5.7 Simulator

During this quarter, several errors were found and corrected in the ILLIAC IV execution simulator. A facility for ascertaining PE usage, i.e., the number of PE's enabled, and for summarizing it was added to the execution and timing simulators. The clock time in the timing simulator was changed from 40 nsec to 50 nsec.

5.8 B5500 Operation

The present status of the MCP is Mark IX, LEVEL 31.14. During April 184.97 hours of processor time were logged. The comparable figure for May is 148.97 hours. Tape storage cabinets and a card file are being ordered for the Tape Documentation library. There are operators on duty during all scheduled operating hours.

5.9 Numerical Analysis

5.9.1 Monte Carlo Transport

The Monte Carlo Transport code was expanded to include one space dimension and three angular dimensions. Problems involving absorption and scattering were compared with closed form solutions given in Chandasekar, and the results were quite good for the number of particles used. There are several ways this program can be expanded to two spatial dimensions and formulated for ILLIAC IV. Among the most prominent alternatives are:

1) Assign a particle uniquely to a PE. This requires that either all cross sections must be stored in a PE or the cross sections must "migrate" among the PE's.

2) Assign a PE to a unique section of the space mesh. This implies that the particles must "migrate". Efficiency requires that the number of particles stored in PE_i be approximately the same as the number stored in PE_j.

3) Assign a PE to a unique section of the space mesh and require that the number of particles handled by each PE be the same. Differences in flux and intensity must then be reflected by particle "weighting".

Analysis of these and other schemes will continue. It is unlikely that the same scheme will be optimum for both linear and nonlinear transport, particularly if fluid motion of the medium is also included.

5.9.2 Multidimensional Compressible Hydrodynamics

Hick's test problems are still being run and plotted on the 360/75 to test various velocity weighting schemes. An interesting pattern is occurring. At the shock front, the "donor" cell scheme gives excellent results--far superior to the other two schemes. But away from the shock front, where the flow is smooth, the "donor" scheme breaks down, and the "OIL" velocity weighting is superior. No scheme works very satisfactorily during the collision of two shocks.

A two dimensional code has been written for the B5500, and properties of the three velocity weighting schemes will be examined in two dimensions.

5.9.3 Polynomial Root Finding

During this quarter, the algorithm for evaluating

$$\int_S \frac{P_n'(z)}{P_n(z)}\,dz \quad ,$$

where the contour S is a square in the complex plane, was tested on the B5500. It was desired to find out how many subdivisions were required in the numberical quadrature, if more accurate methods (Simpson rule or Gaussian Quadrature) were faster, and how near to the contour a root could lie without causing the integration to diverge.

Other strategies for refining roots were also considered. If a root is contained in a square whose dimension is s, then by subdividing it into 64 subsquares and allowing each PE to simultaneously integrate around a subsquare, the uncertainty in the root is reduced to 1/8 s. But using a single processor, the same reduction in the uncertainty can be achieved in no more than 12 quadratures. This suggests that the "efficiency" of the procedure is less than 100% even though all PE's are busy. A more effective strategy is to assign each PE to a root (or divide the PE's in some regular fashion if there are less than 64 roots isolated) and this is being investigated.

5.9.4 Seismic Equation of State

During this quarter, an attempt was made to program an "equation of state" for earth. The thermodynamic equation of state (EOS) gives pressure, P, as a function of density, ρ, and internal energy, E. The EOS is obtained by "fitting" experimental data with a certain function. Unfortunately, this function has a different form over different ranges of ρ, E.

Each PE is considered to contain a value for ρ, and a value for E (64 two-tuples). The subscript on the P's in the following equations represents the function which must be evaluated when the (ρ, E) obeys

the conditions

(I) for $\rho \geq \rho_0 = 2.6$

$$P_S = \left[a + \frac{b}{\frac{E}{E_0\eta^2} + 1}\right] \cdot E\rho + A\mu + B\mu^2 \tag{1}$$

(II) for $\rho < \rho_0 = 2.6$, $E < E_S$,

(a) if $\rho < 2.40214$, then

$$P_1 = -0.740 \left\{ \frac{(\mu + 0.385)[1 + 105(\mu + 0.0761)^2]}{(\mu + 0.0406)[1 + 623(\mu + 0.0761^2]} \right\} \times 10^9 + 0.8624035819 \times 10^6 \tag{2}$$

(b) if $2.40214 \leq \rho < \rho_0$, then

$$P_2 = (\mu + 0.1073)[170 + 1{,}140(\mu + 0.1073)] \times 10^9 + P_{ATM} \tag{3}$$

(III) for $\rho < \rho_0$, $E > E_S$

$$P_V = aE\rho + \left[\frac{bE\rho}{\frac{E}{E_0\eta^2} + 1} + A\rho\, e^{-\beta\left(\frac{V}{V_0} - 1\right)}\right] e^{-\alpha\left(\frac{V}{V_0} - 1\right)} \tag{4}$$

(IV) for $\rho < \rho_0$, $E_S < E < E'_S$

$$P_{S+V} = \frac{1}{E'_S - E_S}\left[(E - E_S)\, P_V + (E'_S - E)P_S\right]$$

in which P_S and P_V must be entered as positive, and they will be set to P_{ATM} if those are negative. (In the above equations, μ, ρ, η, E, V, are parameters, and the others are constants.) The domain (ρ, E) of the conditions is sketched in Figure 1.

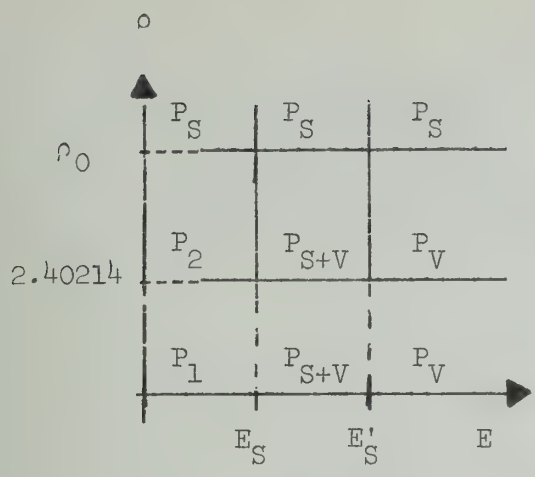


Figure 1

In order to achieve effective parallel computation, the concepts of "factoring" and "embedding" are used. The performance of similar arithmetic operations in different equations at the same time is sought. The similar sequence of arithmetic operations if "factored" or "extracted" as a symbolic form, for example, CONSTANT1 × (PARAMETER + CONSTANT2)^2 commonly occurs in all equations. If

(PARAMETER, CONSTANT1, CONSTANT2) → $(\mu, B, 0)$ for (1)

→ $(\mu, 77.7 \times 10^9, 0.0761)$ for (2)

→ $(\mu, 1{,}140 \times 10^9, 0.1073)$ for (3)

then is assigned to the three-tuple,

$$B\mu^2,\ 77.7 \times 10^9 \times (\mu + 0.0761)^2,\ 1{,}140 \times 10^9\ (\mu + 0.1073)^2$$

can be obtained, at the same time, as a portion of P_S, P_1 and P_2, respectively. For the above parallel computation, the memory allocation for CONSTANT1 and CONSTANT2 for those PE's which need to compute P_S, P_1, P_2 is seen in Figure 2.

	P_S	P_1	P_2	
CONST1	B	77.7×10^9	$1{,}140 \times 10^9$	← PE Memory
CONST2	0	0.0761	0.7073	

Figure 2

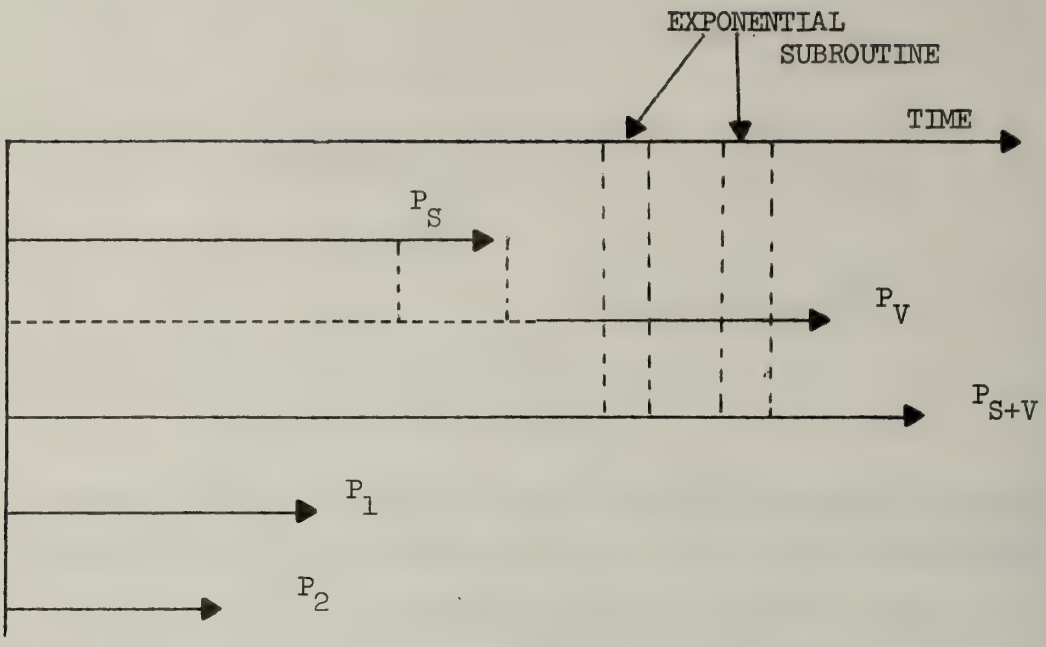


Figure 3

All of P_1 and P_2 can be calculated by complete "embedding" in P_S. Some parts of P_V, which are common P_S, start around the end of P_S. P_S and P_{S+V} are required to call exponential subroutine twice as shown in the figure. A more detailed description will be given in a forthcoming document.

This EOS has been programmed and simulated. It is estimated that no more than 80μs are required to evaluate the EOS for 64 separate two-tuples (ρ,E). If no member of the 64 two-tuples requires evaluation of P_V or P_{S+V}, the time is considerably shorter.

5.9.5 Mathematical Subroutines

The multiple precision divide routine was implemented during this quarter. Now all the arithmetic operations are available as multiple precision subroutines. Work is continuing on the transcendental and trigonometric function subroutines.

5.10 Linear Programming

During this quarter, SSK simulation of the LPS (small linear programming system) code was initiated. Because of the complexity of

the intermediate files, the group intends to conduct a sequential simulation of the routines involved. Thus, each procedure will utilize output from preceding routines as input instead of independently generated data. This will serve as a check on the validity of files produced in each routine as well as eliminate the extra coding and debugging requirements of a necessarily complex intermediate file generator. However, where input requirements are small, routines will be pretested with independent data in order to expedite the main "front end" simulation.

The first segment of LPS is the B6500 preprocessor. Input data must be converted from the user's format and "strewed" across the PEM's in ILLIAC IV disk records. Several interralated disk files (A-matrix, cost row, basis header, right hand side) are initialized here for final preprocessing in PEM's by ILLIAC IV itself. In addition, B6500 tables must be prepared for use in the postprocessing of the solution by the B6500. A preliminary version of a B5500 preprocessor has been completed and largely debugged. The assembly language routine for final preprocessing in PEM has been coded and simulation has begun.

The analysis of stability conditions and techniques for improving accuracy continues. It has been determined experimentally that forcing all bounds to the common value of 1 may have an adverse effect on the sizes of the resulting matrix coefficients. For this reason, different formulas for computing a dynamic, data-based value for the common upper bound are being investigated. For control and prediction of round-off errors, an iterative refinement technique and an L4 reinversion algorithm have been defined. The evaluation of these proposals will continue into the next quarter.

5.11 Long Codes

This quarter was devoted to the study of stochastic processes and the identification problem of linear stationary dynamic systems. The work done by Ho and Lee [1] and Lee [2] in this area was extended to treat a more general case than the one they presented.

Ho and Lee considered the system

$$x_{k+1} = \Phi\, x_k \qquad (1)$$

$$Z_k = h^t\, x_k + v_k$$

where x is the state vector and is of order n; Φ is the n x n transition matrix of the system; Z is the observed scalar; h^t is a row vector of order n; and v_k is a random noise sequence that cannot be measured and is assumed to be Gaussian.

Assuming system (1) to be completely observable [2, 3] and n-identifiable [2], where n is the order of the system, then it was possible to reduce the system to the canonical form [3],

$$y_{k+1} = \left[\begin{array}{c|c} o & I \\ \hline \multicolumn{2}{c}{\varphi^t} \end{array}\right] y_k$$

$$Z_k = (1, 0, \ldots, 0)\, y_k + v_k$$

by the linear transformation $y_k = O\, x_k$, where φ^t is a row vector of order n, and O is the observability matrix of the system.

A least-squares estimate of the vector φ was obtained and was updated as new measurements were observed. Convergence of this stochastic estimation was proved under certain plausible assumptions [1, 2].

Lee's work was extended in an effort to identify the system

$$\begin{aligned} x_{k+1} &= \Phi\, x_k \\ Z_k &= H\, x_k + v_k \end{aligned} \qquad (2)$$

where H is an m x n matrix.

As before, assuming that the system is completely observable and n-identifiable, it was possible to reduce system (2) to a canonical form by means of the linear transformation

$$y_k = B^{-1} x_k$$

where $B = \left[\begin{array}{c|c|c|c} x_o & \Phi\, x_o & \cdots & \Phi^{n-1} x_o \end{array}\right]$ is the n-identifiability matrix, which is of rank by virtue of the above assumptions. A least-squares estimate of the vector φ representing the reduced n-unknowns is obtained. In obtaining that estimate, however, care must be taken that the observations

are spaced in batches of certain size to avoid correlated noise. The identification algorithm of system (2) will be discussed in detail in a forthcoming ILLIAC IV document.

5.12 Radar Data Processing

The Kalman Filtering Tracking program has been completed. It was written in ILLIAC IV Assembly Language using an algorithm developed at Lincoln Laboratory. All operations are done in the 32-bit mode, and all data is represented in Radar Polar coordinates. The whole program has been run on the simulator, and simulated ILLIAC IV computer results have been produced. A document explaining this program and its results is now being written. It should be completed by the end of the next quarter.

The FFT (Fast Fourier Transform) algorithm has been programmed in ILLIAC IV Assembly Language using 32-bit mode. The real and the imaginary parts of a FFT occupy one 64-bit word in each PE; therefore, both are treated simultaneously. A report on this algorithm is presently being generated.

5.13 Seismic Signal Processing

A significant portion of the quarter was spent modifying the statistical programs written during the previous quarter, doing the research necessary for designing digital filters for seismic signal processing, and building a signal processing library system on tape.

The frequency analysis system begun during the last quarter was completed. The system now has the capability of deriving the Fourier Amplitude spectrum of a given time series through the use of the sine and cosine transform or through the Fast Fourier Transform program made available from the Phased Array Radar group.

Some program modifications have been made to improve the data transmission to the various programs and create disk files of data for manipulation by the various seismic system programs. The convolution program has been redesigned to employ the concept of polynomial multiplication used as a transform. This will be useful in future applications. The programs are written in B5500 ALGOL for later conversion to the desired ILLIAC IV language.

5.14 Statistical Packages

During this quarter, the design for the ILLIAC IV statistical system was altered considerably due to personnel restrictions. Before this time, a system with considerable innovation was under design. It has been decided now, however, that the system should be limited to the very basic tools and that no experimentation with input language should be attempted at this time. Therefore, the design will mimic the design of the University of Illinois SOUPAC system originally written on the 7094 and converted to and updated for the IBM 360/75.

The routines which will decode the input language will run on the B6500. The coding of these routines was virtually completed during this quarter. They have also been partially debugged on the B5500. It has been finally decided to write the routines themselves in TRANQUIL. The routines will attempt, however, to use only the simplest features of the language consistent with efficiency on ILLIAC IV. Rough coding and flowcharting has begun on the correlation program. The structure of all the routines themselves will follow the structure of the same programs on the SOUPAC system with the exception of the transformations program and the matrix program. The matrix program on ILLIAC IV will simply access the standard matrix written on ILLIAC IV. The transformations program and the matrix under consideration. It will mimic the operations of the SOUPAC system but will be simplified.

5.15 Burroughs ALGOL to Control Data Corp. 6000 Series ALGOL Conversion

The ALGOL to ALGOL conversion project progressed in two major ways this quarter.

(1) Neglecting input-out related phenomena, stream procedures, and certain items noted in the following section, the ALGOL to ALGOL conversion program can translate working Burroughs ALGOL programs into working CDC ALGOL programs. This was demonstrated by having itself to produce what, with the exceptions previously mentioned, was virtually confirmed to be a syntactically correct, equivalent CDC ALGOL program. This conversion program runs a 600 cards per processor minute.

(2) Computer time on a CDC 6000 series machine was finally obtained at Northwestern University near Chicago. Runs were made on this CDC 6400 to determine what machine code was generated by the CDC ALGOL Compiler for various ALGOL constructs.

CDC ALGOL is almost true ALGOL 60. It uses a general stacking algorithm that is not troubled by the up level addressing problem as is Burroughs ALGOL on the B5500. Also, this ALGOL makes considerable use of descriptors as parameters so that run time attribute testing and conversion (between real and integer only) may be done. Unfortunately, this quite general data structure requires execution time. Tests have demonstrated that simple ALGOL constructs execute in the same, if not more, processor time on the 6400 as on the B5500, even though the 6400 is a considerably faster machine with many more active registers. Procedure cells require five times more processor time on the 6400 than on the B5500.

It was discovered that CDC ALGOL evaluated expressions with no consideration of side effects. These occur frequently in Burroughs ALGOL programs due to the heavy use of imbedded assignments (which are converted to function calls by the conversion program). Runs were made on the 6400 to determine precisely what code was generated for various types of expressions. The conversion program was changed to modify expressions so that the code generated by CDC ALGOL evaluates the elements of an expression such that side effects propagate in the manner intended by the Burroughs ALGOL programmer.

Burroughs ALGOL permits using a sub-array of an array as a procedure argument. The conversion program and the CDC ALGOL utility routines are being modified to simulate this construct.

Various machine language routines for partial word operators, concatenate operators, etc., must be written and debugged. An I/O package must be designed and implemented.

5.16 ILLIAC IV Education

The ILLIAC IV Education courses, CS 491-D and B5500 ALGOL, were successfully completed this quarter. As these courses are again offered, modifications and improvements will be made to them.

The paper describing the contents of the Graduate level CS 491-D, which covered ILLIAC IV hardware, software, and applications was also completed

this quarter. It was written from notes taken in these classes, and in some cases, the lectures were summarized and dictated for the purpose of having them included in the paper.

The plans for creating a program library were modified to include documents, reports, and papers written about ILLIAC IV. This will now be developed as a users library and will be implemented in the coming quarter.

REFERENCES

[1] Ho, Y. C., and Lee, R. C. "Identification of Linear Dynamic Systems," Information and Control, VIII (1965), 93-110.

[2] Lee, R. C. "Optimal Estimation, Identification and Control," Research Monograph, XXVIII, Cambridge, Massachusetts: M.I.T. Press, 1964.

[3] Bucy, R. S., and Joseph, R. D. "Filtering for Stochastic Processes with Applications to Guidance," Interscience Tracts in Pure and Applied Mathematics, XXIII, Interscience Publishers: J. Wilsy, 1968.

THESES

Bernott, Bruce A. "Disk I/O for Non-Core-Contained P.D.E. Meshes and Arrays." Master's Thesis, DCS Report No. 311. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Lawrie, Duncan H. "GLYPNIR: A List Processing Language for ILLIAC IV." Master's thesis, DCS Report No. 322. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Matsushita, Yutaka "A Solution to the Hidden Line Problem." Master's thesis, DCS Report No. 335. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

McCarthy, Thomas E. "An Automatic Integrator for Ordinary Differential Equations for ILLIAC IV." Master's thesis, DCS Report No. 336. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

DOCUMENTS

Grossman, Gary R. "SSK/SSK Reference Manual." ILLIAC IV Doc. No. 217, DCS File No. 798, (June 13, 1969).

Northcote, Robert S., et al. "TRANQUIL: A Language for an Array Processing Computer." ILLIAC IV Doc. No. 215, (April 1, 1969).

Winje, Gilbert L. "Random Number Generators for ILLIAC IV." ILLIAC IV Doc. No. 218, DCS File No. 799, (June 20, 1969).

6. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL LANGUAGES

(Supported in part by the National Science Foundation under Grant No. NSF-GJ-217.)

6.1 Computerized Mathematics

In this quarter we completed the proof of the following theorem; if S is an inconsistent set of clauses and $T \subseteq S$ such that S-T is consistent, then there is a tautology-free refutation of S by resolution with merging with T-support. We have written the first draft of a paper containing this theorem and some remarks on the proofs of metatheorems about resolution. We will revise this paper in the next quarter, and publish it.

Also, in the next quarter, we will begin a survey of higher order logical systems. It is generally felt that the next major advance in automatic theorem proving will be made along these lines.

(L. J. Henschen)

6.2 Numerical Solution of Singular Integral Equations

For the singular integral equation with Cauchy kernel to have meaning, we must assume that the singular integral exists, usually in the Cauchy principal value sense. The dominant part of the equation is basically a Hilbert Transform:

$$f(x) = H_x(g(t)) = \frac{1}{\pi} P \int_{-1}^{1} \frac{g(t)}{t-x}\, dt$$

It is shown in different sources that the Cauchy principal value exists and the transform defines a function in the same class if (1) g(t) is Holder continuous and (2) if g(t) is in L_p ($p > 1$).

Work during the quarter has been concentrated on trying to determine the relationship, if any, between these two results and in particular to determine the most general class of functions, g, such that the Hilbert transform will also belong to this class.

(A. McInnes)

6.3 Study of Methods of Selection of Quotient Digits During Digital Division

This study concerns a class of division techniques in which redundancy is introduced into the representation of the quotient thereby permitting quotient digits to be selected by inspection of estimates of the full precision divisor and partial remainder.

The first several weeks of the quarter were dedicated to another review of the literature in search of additional candidates for quotient selection mechanisms. The results were largely negative in the sense that little additional was found to be of significance to this research. Two relatively new papers are, however, worth noting. Both are available through the IEEE Computer Group Repository.

The first, "A Carry-Independent Quaternary Division Scheme," by R. M. Wade of IBM describes a specific application of the model division technique. Wade's work, although apparently done independently, falls within the theory developed in our earlier work.* It appears that the quotient selection logic was derived largely by trial and error rather than awareness of the theory.

The second paper, "A Suggestion for an High-Speed Parallel Binary Divider," by R. Stefanelli describes a combinatorial network which computes the inverse of a given binary number. Let A, with bits a_i, be the given binary number and Q, with bits q_i, be the inverse of A. The network is based upon the fact that AQ = 0.111111111 ... ≈ 1. It solves the set of equations:

$$q_1 = 1-a_2$$

$$q_2 = 1-(a_2q_1 + a_3)$$

$$\vdots$$

$$q_i = 1-(a_2q_{i-1} + a_3q_{i-2} + \ldots + a_iq_1 + a_{i+1})$$

The Stefanelli method is being studied further.

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* D. E. Atkins, "Higher Radix Division Using Estimeates of the Divisor and Partial Remainders," IEEE Transactions on Computers, Vol. C-17, No. 10, (October 1968), pp. 925-934.

The remainder of the quarter was devoted to the preparation of a report for presentation at the Workshop on the Theory of Computer Arithmetic, June 16, 1969, sponsored by the IEEE Computer Group.** This report describes the use of redundancy and higher radix methods in the design of the arithmetic units for ILLIAC III. The design incorporates a radix four, table look-up model division scheme which controls a full-precision, radix 256, non-restoring scheme.

(D. E. Atkins)

6.4 Automatic Function Generation

The set of elementary function algorithms has been expanded during this quarter to include tangent and arccosine and arcsine. The tangent is formed using a modified version of the cosine/sine algorithm and a terminating division. The difficulties encountered in producing the cosine and sine which make it inefficient to perform the first quarter of the algorithm redundantly are not present in the tangent algorithm because it is not necessary to explicity produce the cosine and sine; rather it suffices to produce scale factor multiples of the cosine and sine since the scale factor disappears during the terminating division. It is necessary also to perform some initial range tests on the operand since over certain ranges a simple one or two term power series approximation yields better accuracy than the algorithm. A time estimate to perform the tangent algorithm is two multiplication cycle times if three adders are available. The algorithm requires no new precomputed constants.

The arccosine and arcsine are evaluated in terms of the arctangent. A multiplication (to form x^2) and a square root (to form $[1-x^2]^{1/2}$) are required first. Thus either the arccosine or arcsine will take approximately three multiplication cycle times assuming three adders.

It is felt that the set of algorithms, which now includes divide, exponential, log, square root, cosine/sine, tangent, arccosine, arcsine, and arctangent, is sufficiently complete. The next segment of research

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* D. E. Atkins, "Design of the Arithmetic Units of ILLIAC III: Use of Redundancy and Higher Radix Methods," Department of Computer Science Report No. 333.

involves a partial simulation of the algorithms to achieve a Monte Carlo estimate of the efficiency of each. Final research will be a study of implementation.

(B. G. De Lugish)

6.5 NUCLEOL

We began work on a system for implementing transformational grammars in terms of NUCLEOL. Some of the basic tree-matching and -transforming routines have been written.

Currently NUCLEOL is being modified to interface with PL/1. Thus in the transformational grammar system, tree transformations will be done in NUCLEOL, and I/O, arithmetic, etc, in PL/1.

(N. Bracha, K. Maruyama, J. Nievergelt)

6.6 Graph Algorithm Research

During this quarter, the graph algorithm software package was made more efficient and easier to use. The package has been expanded so that programmers may express all elementary (and several advanced) operations on sets and graphs in a natural, implementation-independent way.

The system is being tested and expanded by using it to program non-trivial graph algorithms. The needs of these higher-level programs reveal what low-level software is needed. Past tests include Shannon Switching Games and generating all spanning trees of a graph. The next quarter will see a variety of planarity tests implemented.

(S. Chase)

6.7 Switching Theory and Logical Design

The research work I am doing concerns the logical design of optimum networks (the sum of external input connections plus gate interconnections is minimized) of NOR-gates which realize certain 4 variable functions of interest. These networks are found by integer programming.

As mentioned in the last report, solutions had been found for test functions requiring 3, 4, and 5 gates. Since then, certain 6- and 7-gate functions have also been solved.

The first 7-gate function required approximately 40 minutes to solve and so prompted a change to a much faster program written by C. R. Baugh. Another problem was the length of time required to write the inequalities used for problems of 7 or more gates by hand. So another switch was made to program generated inequalities. Several changes were needed to make Baugh's program compatible with the program generated inequalities. Another recent improvement (modified CLSP -- this is a modification of the t-vector described in an earlier report*) was introduced which further improved the speed of Baugh's program.

With this new program and CLSP modifications, the computation time needed to solve the 7-gate problem under consideration was reduced to 1/7 of the previous time.

An attempt was made to obtain an optimum NOR-gate network for an 8-gate function, but it was temporarily suspended due to an estimated run time of 40-60 minutes.

Presently I am trying to find a means to speed up Baugh's program to solve 8-gate problems in a reasonable time.

(J. Culliney)

6.8 A Study of Implicit Iterative Procedure Due to H. L. Stone

Consider the Dirichlet problem for the self-adjoint differential equation

$$(1) \qquad \frac{\partial}{\partial x_1}\left(a_1(x)\frac{\partial}{\partial x_1}U\right) + \frac{\partial}{\partial x_2}\left(a_2(x)\frac{\partial}{\partial x_2}U\right) + f(x)\cdot U = Q(x)$$

where x lies in a bounded plan region, $a_i(x) > \eta_i > 0$, $f(x) \leq 0$ and $a_i(x)$, $Q(x)$, $f(x)$ are sufficiently smooth.

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* T. Ibaraki, T. K. Liu, C. R. Baugh, and S. Muroga, "An Implicit Enumeration Program for Zero-One Integer Programming," Department of Computer Science Report No. 305, January 1969.

The usual five-point discrete analogue of (1) is

(2) $Au = q$

H. L. Stone has suggested that implicit procedure based on approximately factoring the discrete operator A into easily invertible factors might facilitate the solution of (2). Stone considered the implicit procedure

(3) $(A+B)u_{n+1} = (A+B)u_n - \omega(Au_n - q)$

where B is chosen so that

(4) $A + B = LU$

where L(U) is a lower (upper) triangular matrix with no more than three entries per row, and $\omega = 1$.

T. Dupont showed convergence of (3) for a different B. (SIAM Journal on Numerical Analysis, December, 1968).

The following is a lemma of Rachford and Dupont.

Lemma: Let A and A + B be positive definite. Suppose there exist positive numbers e_1 and e_2 such that for all nonzero x we have

$$\frac{\langle Ax,x\rangle}{\langle (A+B)x,x\rangle} \in [e_1,e_2]$$

Then for $0 < \omega < 2e_2^{-1}$ the sequence $\{u_n\}$ defined by (3) converges to $u = A^{-1}q$.

For the Stone iteration I proved that the factorization implies that A+B is positive definite. (I used a factorization technique suggested by Stone so that A+B will be symmetric matrix.) I also obtained estimates on the factors L and U. My present work is to prove that $\omega = 1$ is included in $(0,2e_2^{-1})$, i.e., $e_2 < 2$, which implies that the Stone procedure converges for $\omega = 1$.

Experimental results shows that $e_2 \leq 1.3$.

(A. Bracha)

7. SWITCHING THEORY AND LOGICAL DESIGN

Considerable improvement of the efficiency of ILLIP was made by T. K. Liu, by introducing a concept named "chain-checking of inequalities." When the implicit enumeration method examines whether each inequality is satisfied or not, we can find that some inequalities need not be examined for some partial solutions. The chain-checking of inequalities identifies the next inequality to examine in an efficient way, skipping inequalities which need not be examined. The more inequalities an integer programming problem contains, the more the improvement of efficiency of the implicit enumeration method.

Logical design problems of optimum networks for 3 variable functions were run again with the ILLIP with the chain-checking of inequalities incorporated. The speed improvement of at most two and a half times was observed.

T. K. Liu and L. E. Shiau designed a one-bit adder with different combinations of types of gates.

J. Culliney and T. Nakagawa work on logical design of optimum networks by integer programming, functions of 4 variables, using NOR gates. J. Culliney examined time spent in each subroutine, by making a special program based on Muroga's idea.

R. Swee made a computer program to design optimum networks with NOR-AND gates (i.e. each gate has two outputs, one for NOR and the other for AND) by integer programming. At the inputs of a network only x_1, x_2, x_3 are available but not their complements. This will be Swee's thesis for master degree. C. S. Chandersekaran is working the same

problem, eliminating the last restriction. In other words all x_1, x_2, x_3 and their complements are available at the inputs of a network. The problem is the design of optimum network in double rail logic of NOR and AND.

F. Chen continued to work on his PhD thesis on the design of optimum networks for multiple outputs by introducing multiple-output prime implicants and associated Boolean concepts.

In continuing the investigation of pseudo-threshold logic, C. R. Baugh developed some properties of the Chow parameters and also their relationship with various properties of the function. The concept of an optimum structure for a pseudo-threshold function was developed. Based on this definition an algorithm was designed to determine if a given Boolean function is a pseudo-threshold function; and if it is, to calculate its optimum structure.

S. MUROGA

8. SOUPAC SECTION
(Statistically Oriented Users Programming and Consulting)

During the time period April 1 through June 30, 1969, the 7094 version of SSUPAC ran more than 6600 jobs even though during the period many users were already using the IBM 360 SOUPAC. The 360 SOUPAC is operational and contains 28 programs.

The programs which were on the old system but are missing from the new are either in an advanced state of development or are sufficiently obscure that their absence is not critical. The problem of handling missing data, e.g. MISSING DATA CORRELATIONS, has been resolved and is being implemented. The econometric package is being tested. In addition to THREE STAGE LEAST SQUARES, ECONOMETRIC REDUCED FORMS, and K-CLASS estimators, the package will also contain procedures for Limited Information Estimators, Full Information Estimators, and Aiken Estimators.

The new TRANSFORMATIONS has a number of new techniques which will make simulation of complicated techniques much simplier.

It is projected that the SOUPAC Library may contain 50 programs when the additions currently being considered have been implemented. Some additional data management facilities have also been proposed; namely edit, copy, merge, and accounting facilities.

Members of the SOUPAC staff have given talks for certain offices and institutes on campus and have received favorable comment. Also it was learned at the Spring Joint Computer Conference held in Boston that other computer installations are attempting to implement SOUPAC-like systems.

Kern W. Dickman
Project Director

9. IBM SYSTEM/360 SERVICE

(Supported in part by the National Science Foundation under Grant No. NSF-GP-7634.)

9.1 New Routines - IBM System/360

F2-ACM-EIGENP-89F-F

Eigenvalues and Eigenvectors of a Real, General Matrix. This program will find the eigenvalues and eigenvectors of a real, general matrix using, respectively, the QR double-step method and inverse iteration.

This program was copied from Communications of the ACM, Volume 11, Number 12, (December, 1968). Checked by Richard Isler.

Programmed by J. Grad and
M. A. Brebner

April 11, 1968

Table I - IBM 360/20

Summary of Use

April, 1969

Scheduled Engineering		15:06
Unscheduled Engineering		3:09
Maintenance		4:56
Production		269:09
Idle		236:40
	Total	529:00

Table II - IBM 360/20

Summary of Machine Errors

April, 1969

2560 MFCM		3
2203 Printer		3
	Total	6

Table I - IBM 360/50-75

Summary of Use

April, 1969

Scheduled Engineering	32:46:35		
Unscheduled Engineering	1:22:00		
Idle	9:30:00		
Power Failure	58:00		
Air Conditioning	30:52:00		
		Subtotal	75:28:35
Total Use			
Training and Education		167:59:28	
System Improvement and Modifications		126:06:36	
System Updating		12:27:40	
University Administrative Overhead Use		1:21:02	
Overhead		10:06:03	
Refund		8:35:10	
Customer Use			
In System	126:10:09		
Special Short Shots	1:28:08		
Customer Use Total		127:38:17	
		Total Use	454:14:46
		Total Time	529:43:21

Table II - IBM 360/50-75

Summary of Errors

April, 1969

75 CPU	1
Power Failure	1
Total	2

IBM 360/75 TABLE III APRIL, 1969

DEPT [1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 360/75 USAGE IN HH:MM:SS		
	T AND E [2]	RES	TOTAL	T AND E [2]	RES	TOTAL	T AND E [2]	RES	TOTAL
AAE	856	187	1043	9	7	16	8:11:41	2:25: 2	10:36:43
ACCY	800	0	800	1	0	1	3:49:54	0: 0: 0	3:49:54
AGE	167	117	284	6	7	13	2:57:23	1:32:38	4:30: 1
AGEC	52	271	323	2	13	15	0:28:37	7: 0:45	7:29:22
AGRON	9	280	289	1	4	5	0: 2:15	1:50:36	1:52:51
ANS	0	40	40	0	2	2	0: 0: 0	0: 8:34	0: 8:34
ARCH	649	15	664	3	1	4	7:21: 1	0:11:57	7:32:58
ASTR	0	102	102	0	6	6	0: 0: 0	1:27:52	1:27:52
BADM	113	20	133	4	1	5	1:33:22	0: 5:13	1:38:35
BCMPL	0	10	10	0	1	1	0: 0: 0	0: 1:21	0: 1:21
BECBSR	0	88	88	0	1	1	0: 0: 0	0:43:16	0:43:16
BINRES	0	4	4	0	1	1	0: 0: 0	0: 3: 8	0: 3: 8
CDA	0	17	17	0	1	1	0: 0: 0	0:12:22	0:12:22
CE	1630	563	2193	16	45	61	18:10:16	9:57:52	28: 8: 8
CHE	193	1009	1202	6	30	36	2:22:24	17:36:42	19:59: 6
CRC	0	39	39	0	3	3	0: 0: 0	0:40:41	0:40:41
CSL	0	52	52	0	1	1	0: 0: 0	0:40:22	0:40:22
DCS	11115	346	11461	13	12	25	68:41:24	6:54:38	75:36: 2
DS	0	95	95	0	2	2	0: 0: 0	0:39: 5	0:39: 5
ECON	66	52	118	4	4	8	0:51:50	1:27: 6	2:18:56
ED	13	157	170	2	5	7	0:15:14	1:22:28	1:37:42
EDADM	0	56	56	0	1	1	0: 0: 0	1:59:12	1:59:12
EDPSY	147	0	147	2	0	2	0:27:19	0: 0: 0	0:27:19
EE	3493	657	4150	21	36	57	18:21:48	8:47: 7	27: 8:55
ENGADM	0	104	104	0	1	1	0: 0: 0	2:52:39	2:52:39
ENGCST	0	55	55	0	1	1	0: 0: 0	1: 9:25	1: 9:25
ENGH	287	0	287	1	0	1	1: 7:50	0: 0: 0	1: 7:50
FIN	7	51	58	2	2	4	0: 8:15	0:29:23	0:37:38
FOR	0	35	35	0	1	1	0: 0: 0	0:14: 2	0:14: 2
FT	0	9	9	0	2	2	0: 0: 0	0: 4:19	0: 4:19
GENE	436	9	445	6	1	7	5:32:45	0: 1:50	5:34:35
GEOG	0	6	6	0	1	1	0: 0: 0	0: 0:54	0: 0:54
GEOL	40	215	255	1	4	5	0:39: 1	3:25:45	4: 4:46
GRDCOL	0	14	14	0	1	1	0: 0: 0	0:11:31	0:11:31
HONORS	0	4	4	0	1	1	0: 0: 0	0: 1:15	0: 1:15
HORT	0	4	4	0	1	1	0: 0: 0	0: 2:10	0: 2:10
ICR	0	119	119	0	2	2	0: 0: 0	1:30:13	1:30:13
IE	7	0	7	2	0	2	0: 1: 4	0: 0: 0	0: 1: 4
ILLDMH	0	53	53	0	1	1	0: 0: 0	2: 3:14	2: 3:14
INADM	0	35	35	0	1	1	0: 0: 0	0:53:25	0:53:25
MATH	19	20	39	1	3	4	0: 2:48	1: 0:10	1: 2:58
[illegible]	[illegible]	[illegible]	[illegible]	0	28	28	0: 0: 0	4: 4:36	4: 4:36

MCCL	0	22	22	0	1	1	0: 0: 0	0:28:26	0:28:26
ME	1902	504	2406	22	10	32	18:21:35	6:17:47	24:39:22
MKTG	0	2	2	0	1	1	0: 0: 0	0: 0:55	0: 0:55
MMPE	0	14	14	0	1	1	0: 0: 0	0:12:17	0:12:17
MUSIC	92	0	92	2	0	2	0:29:46	0: 0: 0	0:29:46
NUCE	131	157	288	5	11	16	1:51:21	2: 8:58	4: 0:19
OIR	0	121	121	0	1	1	0: 0: 0	1:32:32	1:32:32
ORME	0	3	3	0	1	1	0: 0: 0	0: 0:22	0: 0:22
PEM	0	39	39	0	2	2	0: 0: 0	0: 7:28	0: 7:28
PHYB	0	72	72	0	2	2	0: 0: 0	1: 7:12	1: 7:12
PHYCS	94	661	755	2	15	17	0:20:12	5:56:55	6:17: 7
PHYSL	29	42	71	1	1	2	0: 2:42	0: 1:42	0: 4:24
PHYX	0	498	498	0	7	7	0: 0: 0	14: 8:42	14: 8:42
POLS	6	15	21	1	2	3	0: 1:59	0:15:54	0:17:53
PSYCH	133	88	221	2	5	7	1:47:35	1: 8: 9	2:55:44
REC	0	12	12	0	2	2	0: 0: 0	0:10:43	0:10:43
SCONS	0	30	30	0	1	1	0: 0: 0	0:22:45	0:22:45
SGS	0	77	77	0	3	3	0: 0: 0	0:39:41	0:39:41
SRL	0	108	108	0	5	5	0: 0: 0	0:48:42	0:48:42
SWS	0	406	406	0	10	10	0: 0: 0	3:28:36	3:28:36
TAM	695	209	904	9	15	24	3:58: 7	2:19: 0	6:17: 7
UOSCR	0	3	3	0	1	1	0: 0: 0	0: 2:25	0: 2:25
USGS	0	1	1	0	1	1	0: 0: 0	0: 2:12	0: 2:12
VPH	0	7	7	0	1	1	0: 0: 0	0: 3:52	0: 3:52
VPP	0	35	35	0	2	2	0: 0: 0	0: 9:11	0: 9:11
WPGU	0	10	10	0	1	1	0: 0: 0	0: 5:47	0: 5:47
ZOOL	0	47	47	0	3	3	0: 0: 0	0:24:18	0:24:18
SUBTOTAL	23181	8602	31783	147	343	490	167:59:28	126:10:39	294:10: 7
DCSSYS[3]	0	4158	4158	0	27	27	0: 0: 0	126: 6:36	126: 6:36
OVRHED[4]	0	5	5	0	1	1	0: 0: 0	10: 6: 3	10: 6: 3
REFUND[5]	0	547	547	0	2	2	0: 0: 0	8:35:10	8:35:10
UADP[6]	0	58	58	0	1	1	0: 0: 0	1:21: 2	1:21: 2
XDCS[7]	0	80	80	0	2	2	0: 0: 0	12:27:40	12:27:40
XMAINT[8]	0	12	12	0	5	5	0: 0: 0	75:28:35	75:28:35
XSSS[9]	0	211	211	0	1	1	0: 0: 0	1:28: 8	1:28: 8
TOTAL	23181	13673	36854	147	382	529	167:59:28	361:43:53	529:43:21

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

IBM 1800 TABLE III APRIL, 1969

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 1800 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
AGE	0	1	1	0	1	1	0: 0: 0	0: 5:40	0: 5:40
CE	0	8	8	0	2	2	0: 0: 0	0:57:29	0:57:29
DCS	7	0	7	1	0	1	0: 0:42	0: 0: 0	0: 0:42
EE	2	21	23	1	3	4	0: 2:36	2:52:33	2:55: 9
VPP	0	10	10	0	1	1	0: 0: 0	1:26:49	1:26:49
SUBTOTAL[3]	9	40	49	2	7	9	0: 3:18	5:22:31	5:25:49
DCSSYS[4]	0	67	67	0	3	3	0: 0: 0	3:14:18	3:14:18
OVRHED[5]	0	0	0	0	1	1	0: 0: 0	2: 4:36	2: 4:36
REFUND[6]	0	2	2	0	1	1	0: 0: 0	0:11:19	0:11:19
XSSS[7]	0	0	0	0	1	1	0: 0: 0	0: 0: 0	0: 0: 0
TOTAL	9	109	118	2	13	15	0: 3:18	10:52:44	10:56: 2

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 Special Short Shots

Table I - IBM 360/20

Summary of Use

May, 1969

Scheduled Engineering		8:02
Unscheduled Engineering		22:28
Maintenance		4:34
Production		325:27
Idle		145:19
	Total	505:50

Table II - IBM 360/20

Summary of Machine Errors

May, 1969

2560 MFCM		12
2203 Printer		1
2020 CPU		1
	Total	14

Table I - IBM 360/50-75

Summary of Use

May, 1969

Scheduled Engineering	54:11:06		
Unscheduled Engineering	11:19:00		
Power Failure	3:05:00		
		Subtotal	68:35:06
Total Use			
Training and Education		202:05:42	
System Improvement and Modifications		166:12:55	
System Updating		7:34:01	
University Administrative Overhead Use		1:45:48	
Overhead		12:38:13	
Refund		10:02:16	
Customer Use			
In System	121:25:55		
Special Short Shots	1:54:43		
Customer Use Total		123:20:38	
		Total Use	523:39:33
		Total Time	592:14:39

Table II - IBM 360/50-75

Summary of Errors

May, 1969

1052 Console Typewriter	1
50 CPU	1
Power Failure	1
2540 Card Reader Punch	1
Total	4

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 360/75 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
AAE	710	193	903	8	8	16	5: 8: 2	3:50:17	8:58:19
ACCY	553	12	565	1	1	2	1:42:50	0:10:21	1:53:11
AGE	223	78	301	6	6	12	2:52:53	0:35:22	3:28:15
AGEC	10	359	369	2	8	10	0: 3:51	8:34: 4	8:37:55
AGRON	3	153	156	1	3	4	0: 2:40	0:51:39	0:54:19
ANS	0	40	40	0	2	2	0: 0: 0	0:11:56	0:11:56
ARCH	824	2	826	4	1	5	11:52:49	0: 1:43	11:54:32
ASTR	0	52	52	0	5	5	0: 0: 0	0:35: 7	0:35: 7
BADM	225	65	290	4	2	6	3:59:49	0:15:20	4:15: 9
BCMPL	0	8	8	0	1	1	0: 0: 0	0: 1: 1	0: 1: 1
BECBSR	0	68	68	0	1	1	0: 0: 0	0:36:47	0:36:47
CDA	0	6	6	0	1	1	0: 0: 0	0: 2:45	0: 2:45
CE	2114	703	2817	21	52	73	22:38:56	10:59:53	33:38:49
CHE	177	816	993	6	31	37	3: 4:52	15: 2: 7	18: 6:59
CRC	0	44	44	0	3	3	0: 0: 0	1:26:39	1:26:39
CSL	0	52	52	0	2	2	0: 0: 0	0:34:44	0:34:44
DCS	8166	484	8650	14	12	26	90:30:54	8:31:46	99: 2:40
DS	0	66	66	0	2	2	0: 0: 0	0:37:56	0:37:56
ECON	128	34	162	5	6	11	2:15:47	0:26:26	2:42:13
ED	180	101	281	2	5	7	1:29:54	0:39:14	2: 9: 8
EDADM	0	26	26	0	2	2	0: 0: 0	0:48:58	0:48:58
EDPSY	104	0	104	2	0	2	0:33:37	0: 0: 0	0:33:37
EE	2187	473	2660	17	31	48	15:20:53	7:12:46	22:33:39
ENGADM	0	103	103	0	2	2	0: 0: 0	2:34:45	2:34:45
ENGCST	0	49	49	0	1	1	0: 0: 0	1: 2:59	1: 2:59
ENGH	270	0	270	1	0	1	1:49:29	0: 0: 0	1:49:29
FIN	41	20	61	3	2	5	0:57:54	0: 4:20	1: 2:14
FOR	0	6	6	0	1	1	0: 0: 0	0: 3:26	0: 3:26
FT	0	16	16	0	2	2	0: 0: 0	0: 4:30	0: 4:30
GENE	584	16	600	6	1	7	3:14:37	0: 3:44	3:18:21
GEOG	0	12	12	0	1	1	0: 0: 0	0: 2:13	0: 2:13
GEOL	75	141	216	1	4	5	1:16:56	1:12:13	2:29: 9
GRDCOL	0	2	2	0	1	1	0: 0: 0	0: 3:40	0: 3:40
HONORS	0	2	2	0	1	1	0: 0: 0	0: 0:47	0: 0:47
HORT	0	16	16	0	2	2	0: 0: 0	0: 4:24	0: 4:24
ICR	0	154	154	0	2	2	0: 0: 0	1: 4:22	1: 4:22
IE	101	0	101	2	0	2	0:26:21	0: 0: 0	0:26:21
ILLDMH	0	150	150	0	1	1	0: 0: 0	2:36:28	2:36:28
INADM	0	45	45	0	1	1	0: 0: 0	1: 5:50	1: 5:50
MATH	16	15	31	1	3	4	0: 5:33	0:36:14	0:41:47
MATRL	0	645	645	0	32	32	0: 0: 0	8:26: 8	8:26: 8
MCBIO	0	27	27	0	4	4	0: 0: 0	0: 9: 9	0: 9: 9

MCCL	0	1	1	0	1	1	0: 0: 0	0: 0:26	0: 0:26
ME	1746	361	2107	23	15	38	19:22:27	5:36: 2	24:58:29
MKTG	0	2	2	0	1	1	0: 0: 0	0: 0:54	0: 0:54
MUSIC	121	1	122	2	1	3	1:14:39	0: 0:12	1:14:51
NUCE	184	157	341	5	16	21	2:25:33	1:25:30	3:51: 3
OIR	0	140	140	0	1	1	0: 0: 0	1:57:50	1:57:50
PEM	0	35	35	0	3	3	0: 0: 0	0:11: 7	0:11: 7
PHYB	0	77	77	0	3	3	0: 0: 0	1: 0:51	1: 0:51
PHYCS	11	524	535	2	16	18	0: 1:30	6: 0:43	6: 2:13
PHYSL	138	37	175	1	2	3	0:16:58	0: 7:10	0:24: 8
PHYX	0	381	381	0	7	7	0: 0: 0	10:38:39	10:38:39
POLS	10	48	58	1	3	4	0:13:36	0:50:18	1: 3:54
PROVST	0	3	3	0	1	1	0: 0: 0	0: 1:18	0: 1:18
PSYCH	75	162	237	4	8	12	1: 7:18	3:32:55	4:40:13
REC	0	34	34	0	3	3	0: 0: 0	0:50:40	0:50:40
SCONS	0	15	15	0	1	1	0: 0: 0	0:10:33	0:10:33
SGS	0	68	68	0	4	4	0: 0: 0	0:34: 8	0:34: 8
SRL	0	102	102	0	5	5	0: 0: 0	0:43:44	0:43:44
SWS	0	368	368	0	8	8	0: 0: 0	2:31:38	2:31:38
TAM	509	187	696	9	13	22	7:55: 4	2:34:46	10:29:50
VPP	0	49	49	0	2	2	0: 0: 0	0:13:54	0:13:54
WPGU	0	5	5	0	1	1	0: 0: 0	0: 4:11	0: 4:11
ZOOL	0	73	73	0	3	3	0: 0: 0	0:56:23	0:56:23
SUBTOTAL	19485	8084	27569	154	364	518	202: 5:42	121:25:55	323:31:37
DCSSYS[3]	0	3143	3143	0	27	27	0: 0: 0	166:12:55	166:12:55
OVRHED[4]	0	4	4	0	1	1	0: 0: 0	12:38:13	12:38:13
REFUND[5]	0	513	513	0	2	2	0: 0: 0	10: 2:16	10: 2:16
UADP[6]	0	41	41	0	1	1	0: 0: 0	1:45:48	1:45:48
XDCS[7]	0	89	89	0	2	2	0: 0: 0	7:34: 1	7:34: 1
XMAINT[8]	0	5	5	0	3	3	0: 0: 0	68:35: 6	68:35: 6
XSSS[9]	0	268	268	0	1	1	0: 0: 0	1:54:43	1:54:43
TOTAL	19485	12147	31632	154	401	555	202: 5:42	390: 8:57	592:14:39

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
8 System Maintenance

IBM 1800 TABLE III MAY, 1969

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			IBM 1800 USAGE IN HH:MM:SS		
	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL	T AND E[2]	RES	TOTAL
AGE	0	1	1	0	1	1	0: 0: 0	0: 0: 0	0: 0: 0
AGRON	0	3	3	0	1	1	0: 0: 0	0: 0: 0	0: 0: 0
CE	0	2	2	0	1	1	0: 0: 0	0: 8:58	0: 8:58
DCS	12	0	12	2	0	2	0: 5:27	0: 0: 0	0: 5:27
EE	15	22	37	1	2	3	1:27: 8	1:25:12	2:52:20
ME	0	0	0	1	0	1	0: 0: 0	0: 0: 0	0: 0: 0
NUCE	0	6	6	0	1	1	0: 0: 0	2:44:57	2:44:57
TAM	21	0	21	1	0	1	4:24: 0	0: 0: 0	4:24: 0
VPP	0	12	12	0	1	1	0: 0: 0	1:32:51	1:32:51
SUBTOTAL	47	46	93	5	7	12	5:56:35	5:51:58	11:48:33
DCSSYS[3]	0	71	71	0	4	4	0: 0: 0	5:11:21	5:11:21
OVRHED[4]	0	0	0	0	1	1	0: 0: 0	0:35:31	0:35:31
REFUND[5]	0	4	4	0	1	1	0: 0: 0	1: 9: 9	1: 9: 9
XSSS[6]	0	0	0	0	1	1	0: 0: 0	0: 0: 0	0: 0: 0
TOTAL	47	121	168	5	14	19	5:56:35	12:41:53	18:38:28

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 Special Short Shots

Table I - IBM 360/20

Summary of Use

June, 1969

Scheduled Engineering		12:43
Unscheduled Engineering		11:02
Maintenance		4:39
Production		363:40
Demonstration		:30
Idle		89:56
	Total	482:30

Table II - IBM 360/20

Summary of Machine Errors

June, 1969

2560 MFCM		5
2203 Printer		2
	Total	7

Table I - IBM 360/50-75

Summary of Use

June, 1969

Scheduled Engineering	43:03:21		
Unscheduled Engineering	10:30:00		
Idle	20:00		
		Subtotal	53:53:21
Total Use			
Training and Education		76:08:06	
System Improvement and Modifications		119:09:32	
System Updating		13:14:53	
University Administrative Overhead Use		1:23:37	
Overhead		4:21	
Refund		12:37:15	
Customer Use			
In System	201:59:15		
Special Short Shots	3:53:33		
Customer Use Total		205:52:48	
		Total Use	428:30:32
		Total Time	482:23:53

Table II - IBM 360/50-75

Summary of Errors

June, 1969

75 CPU	1
Software	3
2402 Tape Unit	1
Total	5

IBM 360/75 TABLE III JUNE, 1969

SECONDS--360/75 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	201	246	447	8909	7871	16780
ACCY	262	33	295	6417	2305	8722
AGE	7	124	131	77	4881	4958
AGEC	133	249	382	6748	14258	21006
AGRON	0	189	189	0	9224	9224
ANS	0	62	62	0	1442	1442
ARCH	123	0	123	6127	0	6127
ASTR	0	69	69	0	2996	2996
BADM	119	7	126	7701	2146	9847
BCMPL	0	4	4	0	34	34
BECBSR	0	22	22	0	637	637
BINRES	0	1	1	0	18	18
CDA	0	3	3	0	30	30
CE	416	1538	1954	14874	95134	110008
CHE	33	1372	1405	6739	91687	98426
CLASS	0	676	676	0	17981	17981
COLCOM	0	14	14	0	305	305
CRC	0	83	83	0	2025	2025
CSL	0	172	172	0	13116	13116
DCS	2432	342	2774	53732	35256	88988
DS	0	48	48	0	3994	3994
ECON	35	56	91	3857	1434	5291
ED	16	47	63	518	930	1448
EDADM	0	21	21	0	1177	1177
EDPSY	59	0	59	1488	0	1488
EE	257	724	981	13453	28232	41685
ENGADM	0	291	291	0	16994	16994
ENGCST	0	119	119	0	8867	8867
ENGH	44	0	44	766	0	766
FIN	0	8	8	0	424	424
FOR	0	50	50	0	1872	1872
FT	0	11	11	0	219	219
GENE	101	7	108	3216	118	3334
GEOG	0	21	21	0	431	431
GEOL	110	111	221	8810	5497	14307
GSA	0	5	5	0	107	107
HORT	0	20	20	0	686	686
ICR	0	139	139	0	6700	6700
IE	17	0	17	5302	0	5302
ILLDMH	0	88	88	0	24407	24407
INADM	0	22	22	0	2975	2975
MATH	6	23	29	1648	5905	7553
MATRL	0	1602	1602	0	95359	95359
MCBIO	0	16	16	0	441	441
MCCL	0	2	2	0	152	152
ME	941	803	1744	84422	39764	124186
MUSIC	153	10	163	4893	240	5133
NUCE	95	269	364	3095	16737	19832
OIR	0	212	212	0	9405	9405
PEM	0	31	31	0	1829	1829
PHYB	0	112	112	0	7572	7572
PHYCS	0	614	614	0	30379	30379
PHYSL	0	28	28	0	371	371

HYX	0	585	585	0	65933	65933
OLS	102	64	166	5924	6871	12795
ROVST	0	22	22	0	483	483
SYCH	9	195	204	439	15500	15939
EC	0	9	9	0	649	649
CONS	0	46	46	0	2166	2166
GS	0	139	139	0	4194	4194
OC	0	16	16	0	187	187
RL	54	104	158	3208	939	4147
WS	0	424	424	0	15870	15870
AM	192	180	372	7585	8557	16142
PH	0	3	3	0	213	213
PP	0	36	36	0	803	803
TED	0	10	10	0	623	623
PGU	0	3	3	0	87	87
OOL	3	88	91	125	3529	3654
UBTOTAL	5920	12640	18560	260073	741168	1001241
SSYS[3]	0	3138	3138	0	428972	428972
VRHED[4]	0	40	40	0	261	261
EFUND[5]	0	317	317	0	45435	45435
ADP[6]	0	32	32	0	5017	5017
OCS[7]	0	148	148	0	47693	47693
MAINT[8]	0	28	28	0	194001	194001
SSS[9]	545	0	545	14013	0	14013
OTAL	6465	16343	22808	274086	1462547	1736633

See list of departmental codes following
Training and Education
System Improvement and Modifications
System Use in Excess of User Estimated Usage
Rerun of User Jobs Due to Machine or System Error
University Administrative Overhead Use
System Updating
System Maintenance
Special Short Shots

IBM 360/75 TABLE III 2ND QUARTER,1969

SECONDS--360/75 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	1767	625	2392	56892	30390	87282
ACCY	1615	45	1660	26381	2926	29307
AGE	397	319	716	21093	12561	33654
AGEC	195	879	1074	8696	70347	79043
AGRON	12	622	634	295	18959	19254
ANS	0	142	142	0	2672	2672
ARCH	1596	17	1613	75357	820	76177
ASTR	0	223	223	0	10375	10375
BADM	457	92	549	27692	3379	31071
BCMPL	0	22	22	0	176	176
BECOSR	0	178	178	0	5440	5440
BINRES	0	5	5	0	206	206
CDA	0	26	26	0	937	937
CE	4160	2794	6954	161826	170048	331874
CHE	403	3091	3494	26375	206197	232572
CLASS	0	676	676	0	17981	17981
COLCOM	0	14	14	0	305	305
CRC	0	166	166	0	9665	9665
CSL	0	275	275	0	17622	17622
DCS	21713	1172	22885	626870	90840	717710
DS	0	209	209	0	8615	8615
ECON	229	142	371	15114	8246	23360
ED	209	305	514	6826	8232	15058
EDADM	0	103	103	0	11267	11267
EDPSY	310	0	310	5144	0	5144
EE	5931	1813	7744	134814	85120	219934
ENGADM	0	498	498	0	36638	36638
ENGCST	0	250	250	0	18126	18126
ENGM	601	0	601	11405	0	11405
FIN	48	79	127	3969	2447	6416
FOR	0	91	91	0	2920	2920
FT	0	36	36	0	748	748
GENE	1121	32	1153	34858	452	35310
GEOG	0	39	39	0	618	618
GEOL	225	467	692	15767	22175	37942
GRDCOL	0	16	16	0	911	911
GSA	0	5	5	0	107	107
HONORS	0	6	6	0	122	122
HORT	0	40	40	0	1080	1080
ICR	0	412	412	0	15975	15975
IE	125	0	125	6947	0	6947
ILLDMH	0	291	291	0	41189	41189
IMADM	0	102	102	0	10130	10130
MATH	41	58	99	2149	11689	13838
MATRL	0	2833	2833	0	143420	143420
MCBIO	0	71	71	0	1792	1792
MCCL	0	25	25	0	1884	1884
ME	4509	1668	6257	220264	82593	302857
MKTG	0	4	4	0	109	109
MMPE	0	14	14	0	737	737
MUSIC	366	11	377	11158	252	11410
NUCE	410	583	993	18509	29605	48114
OIR	0	473	473	0	22027	22027

ORME	0	3	3	0	22	22
PEM	0	105	105	0	2944	2944
PHYB	0	261	261	0	15255	15255
PHYCS	105	1798	1903	1302	73437	74739
PHYSL	167	107	274	1180	903	2083
PHYX	0	1464	1464	0	155174	155174
POLS	118	127	245	6859	10843	17702
PROVST	0	25	25	0	561	561
PSYCH	217	445	662	10932	32364	43296
REC	0	55	55	0	4332	4332
SCONS	0	91	91	0	4164	4164
SGS	0	280	280	0	8564	8564
SOC	0	16	16	0	187	187
SRL	54	314	368	3208	6485	9693
SWS	0	1198	1198	0	37484	37484
TAM	1396	576	1972	50376	26183	76559
UOSCR	0	3	3	0	145	145
USGS	0	1	1	0	132	132
VPH	0	10	10	0	445	445
VPP	0	120	120	0	2188	2188
VTED	0	10	10	0	623	623
WPGU	0	18	18	0	685	685
ZOOL	3	208	211	125	8370	8495
SUBTOTAL	48580	29295	77875	1592383	1632562	3224945
OCSSYS[3]	0	10436	10436	0	1481343	1481343
OVRHED[4]	0	49	49	0	82117	82117
REFUND[5]	0	1377	1377	0	112481	112481
UADP[6]	0	131	131	0	16227	16227
XDCS[7]	0	317	317	0	119794	119794
XMAINT[8]	0	45	45	0	712622	712622
XSSS[9]	1024	0	1024	26184	0	26184
TOTAL	49604	41650	91254	1618567	4157146	5775713

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

IBM 360/75 TABLE III JUNE, 1969

SECONDS--1800 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGRON	0	7	7	0	4021	4021
CE	0	5	5	0	857	857
COLCOM	0	14	14	0	1287	1287
CRC	0	5	5	0	3277	3277
EE	0	19	19	0	5487	5487
FT	0	1	1	0	273	273
NUCE	0	19	19	0	23802	23802
PHYSL	0	8	8	0	2438	2438
VPP	0	3	3	0	836	836
SUBTOTAL	0	81	81	0	42278	42278
DCSSYS[3]	0	12	12	0	491	491
REFUND[4]	0	1	1	0	57	57
TOTAL	0	94	94	0	42826	42826

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error

IBM 360/75 TABLE III 2ND QUARTER,1969

SECONDS--1800 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGE	0	1	1	0	340	340
AGRON	0	7	7	0	4021	4021
CE	0	15	15	0	4844	4844
COLCOM	0	14	14	0	1287	1287
CRC	0	5	5	0	3277	3277
DCS	18	0	18	369	0	369
EE	17	62	79	5384	20952	26336
ET	0	1	1	0	273	273
NUCE	0	25	25	0	33699	33699
PHYSL	0	8	8	0	2438	2438
TAM	21	0	21	15840	0	15840
VPP	0	25	25	0	11616	11616
SUBTOTAL	56	163	219	21593	82747	104340
DCSSYS[3]	0	148	148	0	30830	30830
OVRHED[4]	0	0	0	0	9607	9607
REFUND[5]	0	7	7	0	4519	4519
TOTAL	56	318	374	21593	127703	149296

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error

LIST OF DEPARTMENT CODES

The following list of codes are those codes for which the Department of omputer Science has on file one or more authorized signatures. If your epartment or office does not appear on this list, please write its full name n the department field on the Problem Specification Form even though it may equire more than 6 characters.

AE	Aero. and Astro. Eng.
CCREC	Accounts Receivable
CCY	Accountancy
CTGDV	Accounting Division
DV	Advertising
FS	Air Force Science
GE	Agricultural Eng.
GEC	Agricultural Economics
GED	Agricultural Ed.
GREXT	Agricultural Extension
GRON	Agronomy
LUMNI	Alumni Assoc.
MCDEC	Adolf Meyer Center Decatur Ill.
NS	Animal Science
NTH	Anthropology
RCH	Architecture
RT	Art
STR	Astronomy
UDIT	Auditing Division
VI	Aviation
ADM	Business Admin.
AND	Band
CMPL	Bureau of Community Planning
ECBSR	Bureau of Econ. and Bus. Res.
ED	Business Ed.
EDRES	Bureau of Ed. Res.
INRES	Bureau of Institutional Res.
IOPH	Biophysics
OT	Botany
URSAR	Bursar's Office
E	Civil Eng.
ERE	Ceramic Eng.
HE	Chemistry and Chemical Eng.
ICBIO	Comm. Inst. Coop. Bio. Grad. Prog.
IRCE	Cen. for Instr. Res. and Curr. Ev.
LASS	Classics
MPTOL	Comptroller's Office
OMM	Communications
P	City Planning
PUBS	Champaign Public Schools
RC	Children's Res. Center
SL	Coordinated Science Lab.
URLAB	Curriculum Lab.
ZR	Center for Zoonoses Res.
ANCE	Division of Dance
CS	Dept. of Computer Science
GS	Division of General Studies (LAS)
NSTUD	Dean of Students
NW	Dean of Women
OW	Division of Waterways
S	Dairy Science
SFA	Dept. of Stud. Fin. Aid
UE	Division of University Ext.
ECON	Economics
ED	College of Ed.
EDADM	Educational Admin. and Super.
EDPSY	Educational Psychology
EE	Electrical Eng.
ENGADM	Engineering Admin.
ENGCST	Engineering College and Station
ENGH	Engineering Honors Program
ENGLSH	English
ENTOM	Entomology
FIN	Finance
FOR	Forestry
FR	French
FT	Food Science
GENE	General Eng.
GEOG	Geography
GEOL	Geology
GER	Germanic Languages and Lit.
GRDCOL	Graduate College
GRK	Greek
GSA	Graduate Student Assoc.
HACDMH	Herman Adler Zone Center Champaign
HEC	Home Economics
HED	Health Ed.
HIST	History
HLTHSV	Health Services
HONORS	Honors Program
HORT	Horticulture
HOUDIV	Housing Division
HYG	Hygiene
ICR	Inst. of Communications Res.
IE	Industrial Eng.
IGPA	Inst. of Government and Public Affair
ILLCF	Illini Christian Fellowship
ILLDMH	State of Ill. Dept. of Mental Health
ILR	Inst. of Labor and Industrial Rel.
INSTTV	Instructional TV
IREC	Inst. for Res. on Except. Children
ISEDAD	Ill. St. U. Dept. of Ed. Admin.
ITAL	Italian
JOURN	Journalism
LA	Landscape Architecture
LAS	Liberal Arts and Sciences
LAT	Latin
LAW	Law
LIBS	Library Science
LING	Linguistics
MATH	Mathematics
MATRL	Materials Res. Lab.
MCBIO	Microbiology
ME	Mechanical Eng.
MILS	Military Science
MKNLY	McKinley Hospital

MMPE	Min. Met. and Petr. Eng.
MUSIC	Music
NHS	Natural History Survey
NS	Naval Science
NUCE	Nuclear Eng.
OAC	Office of Agricultural Comm.
OAS	Office of Admin. Studies
OIR	Office of Instr. Resources
PEM	Phys. Ed. for Men and Grad PE
PERRIF	Pershing Rifles
PEW	Phys. Ed. for Women
PHIL	Philosophy
PHYB	Physics Betatron Lab.
PHYCS	Physics
PHYPLA	Physical Plant
PHYSL	Physiology
PHYX	Physics Project X
PLPA	Plant Pathology
POLS	Political Science
PORT	Portuguese
PROVST	Provost's Office
PSDEC	Spec. Ed. Decatur Public Schools
PSYCH	Psychology
PSYTR	Psychiatry
PUR	Purchasing Division
REC	Recreation
RHET	Rhetoric
RSOC	Rural Sociology
RTV	Radio and Television
RUSHIS	Russian and area Studies
SCONS	Soil Conservation Service
SCS	Student Counseling Service
SGS	State Geological Survey
SHCBRC	Small Homes Council
SLAV	Slavic Languages and Lit.
SOC	Sociology
SOCW	Social Work
SOLS	School of Life Sciences
SPAN	Spanish
SPCH	Speech and Theatre
SPED	Special Ed.
SRL	Survey Research Lab.
SWS	State Water Survey
TAM	Theoretical and Applied Mechanics
UADP	Univ. Admin. Data Processing
UCCTE	U-C Council on Teacher Ed.
UNIHI	Univ. High School
UOSCR	Univ. Off. of School and Coll. Rel.
URPLAN	Urban Planning
USGS	U. S. Geological Survey
VAH	Vet. Anatomy and Histology
VCM	Vet. Clinical Medicine
VMS	Vet. Medical Science
VPH	Vet. Path. and Hygiene
VPP	Vet. Phys. and Pharm.
VTED	Vocational Ed.
WPGU	WPGU Radio Station
ZOOL	Zoology

Chicago Circle

CCARCH	Architecture
CCCHE	Chemistry
CCDME	Materials Engineering
CCENEN	Energy Engineering
CCGEOL	Geology
CCPHCS	Physics
CCPSYC	Psychology
CCSCS	Stud. Counsel. Service
CCSOC	Sociology

Chicago Medical Center

MCCL	Med. Cen. Comp. Lab.
ORME	Off. of Res. in Med. Ed.
OT	Occupational Therapy

Ill. State University, Normal

ISEDAD	Dept. of Ed. Admin.

Western Ill., Macomb

WIULAB	West. Ill. Univ. Lab School

9.3 Research Problem Specifications

During the second quarter of 1969, 182 problem specifications were submitted to the Department for computation on the System/360. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

2421 Physics. Correlated Analysis of Neutron Cross Sections. Computer programs for data evaluation simultaneously handling several independent data sets such as the data obtained from total, fission, capture, and scattering neutron cross section measurements are being developed. Several versions of such a program are envisaged and will be tested by analyzing U-235 and Pu-239 neutron cross section data in the resolved resonance region. (F. T. Adler)

2423 T Electrical Engineering. Array of Finite Plates. Calculation of the scattered EM fields from an array of parallel plates of finite width due to a wave incident at various angles. (Kent)

2424 T Electrical Engineering. Surface Wave on a Corrugated Surface. The problem is the determination of the mode amplitudes and propagation constants for a surface wave on a dielectric filled, corrugated structure. These constants will be calculated for various physical dimensions of the corrugated surface. (King)

2425 T Electrical Engineering. Antenna Synthesis Problem. To solve antenna synthesis problems by various stable methods. (H.S.Cabayan)

2427 Medical Center Computer Laboratory. Med. Center Research. This project is a preliminary evaluation of the 360 for use on projects of the Medical Center. (Albert Kilburn)

2428 Survey Research Laboratory. Data Management and Program Development. For the development of special statistical programs, and for the storage and retrieval of survey data. (Klecka)

2434 T Civil Engineering. Bacterial Growth on Sand Filters. Deterioration in filtered water quality in iron removal plants has been reported to be due to the bacterial growths on sand filters. Control of such bacterial growths by chemical disinfecting agents appears to be a practical solution. (Baliga)

2435 University of Illinois Commerce. Consulting. Automatic processing of test data for consulting work. (Gear)

2436 Education. Learning Disabilities Research Project. Idiographic analysis of observed tutorial sessions in Remedial Reading with emotionally disturbed children. The study intends to explore both the cognitive and affective aspects of overcoming the reading deficit in a 1 to 1 relationship between student and teacher. Pre and Post Test data as well as the tutoring sessions are utilized in the analysis. (A. Bannatyne)

2437 Education. Organizational Characteristics of High Schools. This project involves analyses of relationships between selected organizational characteristics of thirty-six high schools in Illinois. The variables are measures of innovativeness, complexity and satisfaction of teachers. The problem is to use correlational, analysis of variance and covariance, and central tendency statistics to test research hypotheses concerning how these variables are related. (Fred D. Carver)

2438 T Agricultural Economics. Supply Responses in 15 US Fluid Milk Markets. The problem involves different supply studies in 15 Federal Order milk markets on a cross-sectional and time-serial basis. The statistical analysis will include matrix transformations, multiple regression and linear programming. (R. E. Logeais)

2439 T Physical Education for Men. Computerization of Physical Fitness Data. To develop a means of handling data for various physical fitness parameters through a computer--includes conversion procedures, standard score formation, and utilization of common statistical procedures (mean, standard deviation, correlation, etc.). (Paula L. Schutt)

2442 Nuclear Engineering. Shielding Benchmark Problems. The method of moments will be used to calculate the spatial, energy, and angular dependence of the gamma ray flux in the vicinity of point and plane isotropic, Cs^{137} and Co^{60} gamma ray sources. It is expected that the calculation will first be done for point sources and then the results for plane sources will be calculated by superposition of the point source results. (E. E. Morris)

2445 Chemistry. Numerical Analysis of Data and Models. This number will replace 7094 PS# 69016. (I.C. Paul)

2446 T Agricultural Economics. Evaluation of Models Useful For Planning. Different models useful for planning shall be specified and evaluated with respect to data inputs and outputs generated and their validity with regard to planning the agricultural sector in India will be tested. (S.P. Pant)

2447 T Theoretical and Applied Mechanics. Creep of an Uniaxial Continuous-Fiber-Reinforced Composite Material. The typical element of a uniaxial composite member will be analyzed for creep deformations by a finite element analysis. The results of this analysis will then be compared to simpler creep analyses of composite structures, and conclusions will be made as to the applicability of the different solutions. (Branca)

2449 T Physical Education for Men. Physical Fitness Changes in a Physical Education Independent Study Program as Compared with Traditional P.E. at the Secondary Level. To test for significant difference of improvement on selected physical fitness measures between two groups of high school boys. Each group is sub-divided into three age groups (16, 17, 18). The t test will be used to compare the sub-groups to find out if there is significant difference on T_1. If not, analysis of variance will be used to test for a difference of improvement to T_2. If so, analysis of covariance will be used. (Sherwin Kittleson)

2450 Mathematics. Problems in Number Theory. A computer search for a dependence relation for the Zeros of the Zeta function. (P.T. Bateman)

2451 T Anthropology. Social and Demographic Variables of Population Genetics. Analysis of demographic and genetic data collected in South India. (Russell Reid)

2452 T Business Administration. Demand Analysis. Analysis of the factors underlying the demand for imported automobiles in the United States. (W. D. Seitz)

2453 Business Administration. Legal Research. An analysis of the time and money spent on research by lawyers in the State of Illinois. (W. D. Seitz)

2454 T Educational Administration and Supervision. Doctoral Dissertation. Dissertation on the role perceptions of Professors of Air Science. (McCleary)

2458 T Civil Engineering. Finite Element Analysis of Translational Shells. Finite element analysis of translational shells. (T. C. Chu)

2459 Coordinated Science Laboratory. Card Processing. This number will be used for 360/20 time for various CSL research projects. (H. Gene Slottow)

2460 T Chemistry. Surface Flow Rheology. Surface flow rheology to get viscosity and diffusivity, etc. (Win-Sow Ho)

2461 T Mining, Metallurgy and Petroleum Engineering. Stochastic Theory of River Meanders. Spectrum analysis is performed on statistically generated meanders and natural river courses. (A. E. Scheidegger)

2464 University Office of School and College Relations. Administrative Research on Admissions Procedures. Administrative research dealing with admissions. (Loeb)

2465 Chicago Circle Student Counseling Service. Strong Vocational Interest Blank Scoring. Scoring the Strong Vocational Interest Blank for students who have taken the Freshman Guidance Tests at Chicago Circle. (James Creaser)

2466 T Electrical Engineering. Optical Density Calculations. Calculate the optical density of a Fabry-Perot Interferometer with a periodically varying spacing. (Hunsinger)

2467 T Finance. Non-Forfeiture Value Insurance Pricing Model. The problem is a pricing model based on non-forfeiture values and the face of the policy as a basis for determining the cost of protection per $1000 of the full amount of risk plus the amount of risk from paid-up, reduced face additions. This problem will be run concurrently with the Belth pricing model to examine any similarity in results. (Richard Rudolph)

2468 Civil Engineering. Research Project IHR - 64. Analysis of Fatigue Data - Scanning of data and computation and plotting of S-N Curve. (W. H. Munse)

2469 T Electrical Engineering. P-I-N Characteristics. Numerical integration of equations for current flow and free carrier densities in p-i-n diode in the presence of deep trap (Au, Zn, Co, etc.). (Harry R. Zwicker)

2471 T Horticulture. Genetic Study of the Inheritance of Tomato Calyx Morphology. Statistical works of genetic research. (Mel Chih-Yu Chu)

2472 Classics. Concordance of Homer's Odyssey and Iliad. KWIC concordancing of certain parts of the Odyssey, word frequency counts, listing of metrical word-types with the location of certain words within lines; reverse index. (John J. Bateman)

2473 T Education. Auditory Language Processing. Distributions, frequency counts, correlations, Chi squares. (Marsha Roit)

2474 T Civil Engineering. Analysis of the Operation of Surface and Ground Water Storage Systems. This study is concerned with the application of dynamic programming to the evaluation of the operation efficiency of surface and ground water storage systems. The conjunctive operation of these systems will be simulated for the optimum economic benefits. (M. Heidari)

2475 T Chemistry. Vibrational Spectra. This research is to obtain infrared and Raman spectra and to do the normal coordinate analysis of sulfur modification S_{12}. (R. L. Belford)

2476 Civil Engineering. Elevator System on Construction Sites. Study of elevator systems on construction sites to deliver laborers, materials and tools. Queuing theory will be used to simulate traffic of laborers, materials and tools and elevators. Delivery rate of elevator system will be forecasted and compared with field observations. (C. C. Tung)

2477 Materials Research Laboratory. Junction Transport Theory. Calculation of current flow in metal-semiconductor, metal-insulator-semiconductor junctions. Evaluation of low-energy-diffraction intensities from metallic surfaces. (C. B. Duke)

2478 T Chemistry. NMR and Kinetics Curve Fitting. Calculation of energy levels and iterative fitting of observed nmr spectra, line shape analysis for kinetics of nmr exchange studies, and least-squares fitting of concentration-time data for reactions of metal complexes in solution. (J. K. Beattle)

2479 Forestry. Plantation Management. Analysis of inventory data involving frequency counts, analysis of variance, correlations and regression analysis. (R. W. Lorenz)

2481 T Nuclear Engineering. X-Ray Time of Emission Study. An analysis of time of emission of X-rays produced by internal conversion de-excitation of excited fission fragments of the thermal neutron fission of U- 235 is being done. (Lerche)

2482 Education. Kentucky Evaluation Project. Scoring and analysis of data from a pre-post-test course evaluation. Data to construct several scale scores has been gathered. (James Gulden)

2483 T Materials Research Laboratory. Heat Capacity Data Fitting. Experimental heat capacity data is to be fitted to the functional form $C = B_1 E^{-d} + B_2$ by a least squares variational procedure. (Robert Hempstead)

2484 Recreation. Skokie Community Survey. Analysis of demographic variables and measures of leisure behavior, attitudes and opinions of a random sample of citizens in Skokie, Illinois. (G. Lowrey)

2485 Psychology. Missing Data Solution. Series of factor analyses to fill in missing data in a data matrix. (Inn)

2486 T Theoretical and Applied Mechanics. Computer Simulation of Cyclic Stress Strain Behavior. An attempt is being made here to simulate the cyclic stress strain behavior of metallic materials. This simulation is done through means of a mathematical model which can reproduce the shape of a hysteresis loop and also be aware of previous load history. (J. Martin)

2487 T Aeronautical and Astronautical Engineering. On the Statistical Aspects of a Viscoelastic Stress-Strain Relationship. The problem is to examine the response of a viscoelastic model due to randomly distributed material properties, especially of a beta distribution. A least square probability-density- functions fit is used in order to determine the parameters (a, b) of a beta distribution from a known set of data. Newton-Raphson method is used to solve for the exponents (a, b). (J. Hsu)

2488 Mechanical Engineering. Computer Workshop in A/C Design. The computer will be used for problem checkout and execution of participant's problems for the Computer Workshop in Air Conditioning Design which will be held from June 9 to June 13, 1969. (Pedersen)

2489 Mechanical Engineering. Transient Radiative Transfer. The interaction of conductive and radiative transfer within participating media under time-dependent conditions is being studied for gray and non-gray materials. The governing equation is a non-linear partial differential integral equation for which standard analytical and numerical solution methods are unavailable. A numerical method of solution has been developed and is being employed to study the physical phenomena. (R. G. Hering)

2490 Food Science. Biochemistry of Sporulation of Thermophilic Anaerobes. The study of the distribution of C^{14} from various substrates into the metabolic end products of this particular organism at various stages of growth and sporulation. (John Ordal)

2491 Political Science. Disk Space Supervision. This time will be used to allocate space on the department's disk to its faculty and students and to supervise the use of that space. It may also be used for program development. (William Klecka)

2493 T Agricultural Economics. Soybean Study. Estimation of production function and study of sampling problems in the estimation of costs and returns in farming. (J. R. Jindia)

2494 Physical Education for Men. Proprioception Experiment. Proprioception experiment - 4 treatments and 40 subjects. (Richard T. Trimble)

2495 State Geological Survey. Permeability of Fine Grained Sediments. This is a study of the movement of water through fine grained earth material, such as glacial till. Emphasis is placed on field determination of the permeability and other physical properties of these materials. (Cartwright)

2497 Survey Research Laboratory. 041 - Nursing Study - Data Reduction. Data preparation of 27,000 nursing questionaires. (Uchida)

2498 Economics. Regression and Further Analysis of Company Data. Analysis of growth of firms. (Ayal Eliezer)

2500 Theoretical and Applied Mechanics. Field Method for Shells. Study of transformation of differential equations into a form which is less sensitive to the length of interval between end points. Application to shell structures. (Robert E. Miller)

2501 Civil Engineering. Stress Concentrations by Finite Element Analysis. Solution of problems concerning stress concentrations of various types -- holes, notches, and changes in section, will be accomplished by the finite element method. The best solution involving the fewest elements and the least amount of computer time will be sought. (Michael B. Stetson)

2502 T Department of Computer Science. NOR - OR Synthesis By Integer Programming. Optimal logic circuits of NOR-OR gates will be synthesized by using integer programming. Optimal circuits will be obtained for all three variable Boolean functions. (Richard Swee)

2503 T Aeronautical and Astronautical Engineering. Attenuation of Transfer Matrix. It is sought to determine the measure of the attenuation of a transfer matrix of a periodic beam structure as the number of spans between the input and output locations increases.

The equations will comprise trigonometric, exponential, and natural Logarithmic functions as well as algebraic operations. (Kenichi Doi)

2504 T Nuclear Engineering. Fission Fragment Mass Distribution Study. An analysis of the mass distribution of fission fragments from the thermal fission of U-235. (Sullivan)

2505 T Recreation. Analysis of Water Resources Recreation Literature. The IBM 360 Document Processing System will be used to enable this investigator to receive, using key word inputs, those bibliographical notations that are pertinent to his request. This bibliographic retrieval process will be used to classify according to a topical outline model pieces of literature providing insight into concepts and scientific results of research developed in numerous allied disciplines. A "State-of-the-Art" paper will be developed which will deal with and illuminate the most apparent

relationships involved in the recreational aspects of water resources use, planning and development. (R. B. Ditton)

2506 Microbiology. Sedimentation of Ribosomal Proteins. The molecular weights of ribosomal proteins will be determined by sedimentation equilibrium studies. The M calculations will be made from microcomparitor readings of photographic plates taken after the centrifuge reaches equilibrium. The M_w is determined from XY plots of vertical fringe displacement vs R^2. (Sypherd)

2509 T Electrical Engineering. Ionospheric Photoelectron Studies. A Monte Carlo technique is to be used to study the energy and pitch angle distributions of ionospheric photoelectrons in the ionospheric F-region. Other problems, such as dynamical processes in the F-region, may also receive attention. (R. J. Cicerone)

2510 T Geography. Commodity Flow Analysis of TOFC. The problem will be completed in two parts. The first part involves plotting and describing the movement of goods by Trailer-on-Flatcar. This will involve summing many individual movements into a single "flow" for a given time period. The second part of the problem is to establish what factors are important in determining whether a given flow will take place. Correlation and Regression analysis will be applied to several variables for a number of sampled commodities. (Walcott)

2511 Civil Engineering. Probabilistic Approach to Earthquake Problems. A comparison of the results obtained by deterministic and probabilistic procedures for earthquake problems will be made. (J. Gungor)

2514 Agronomy. Field and Chamber Radiation Studies. Calibration, computation and plotting of energy fluxes exchanged between plant and atmosphere in growth chambers and under field conditions. (Peters)

2515 T Recreation. Height Preferences - A Study of the Vertical Dimension of Children's Play Activity. Considering the effect of the vertical dimension on the overall movement of children during play in a play-room. The horizontal plane has been the only area of movement pattern studied up to now. To what extent does movement "up-down" effect the total movement; how does this affect children individually; as a group; gp relationships; - increasing over time? or decreasing? Increase or decrease wrtxy (horiz) movement. (McQuarrie)

2516 T Sociology. Social Mobility and Extended Kinship Relations. This request for a problem specification number is due to the upcoming closing down of the IBM 7094. This new number merely replaces the old number on the 7094, which is 7D035. (Mindel)

2517 Civil Engineering. Hydraulic Resistance. Numerical analysis and data processing of problems of hydraulic resistance in alluvial channels. (Yen)

2518 Engineering College and Station. Applications of Linear Programming and Associated Techniques. Research in the application of linear programming and associated techniques to various types of optimization problems. (I. W. Marceau)

2519 T Psychology. Responses to Smoking in the Presence of Anxiety Cues. The research is designed as a 3-way multivariate analysis of variance. The 3 factors are: 1) sex, 2) status as heavy or light smoker, 3) smoke or no-smoke instruction. The following dependent variables were recorded: 1) heart rate, 2) skin conductance, 3) evoked responses (GSR), 4) muscle potential, 5) subjective rating of anxiety, and 6) the S-R Inventory of Anxiousness. Some of these variables are measured at more than one point in time so there are a total of 21 dependent variables. (Bowen)

2520 Agricultural Engineering. Physical Properties of Agricultural Products. Damage to shelled corn and soybeans will be determined and analyzed as a function of distance transported. Mixing coefficients will be determined for samples obtained from a 3000-bushel bin of shelled corn. Relaxation and creep data for corn kernels will be analyzed. (G. E. Hall)

2522 T Civil Engineering. Structural Dynamics. Re-evaluation and extension of the procedures for dynamic analysis of structures with emphasis on earthquakes. (Gabriel Estrada)

2523 T Civil Engineering. Optimum Sample Intervals for Water Quality Monitoring. The problem will involve the analysis of a long series of water quality data to describe trends, oscillations, and random variations followed by re-analysis of successively smaller samples of the data to determine how frequently measurements would be needed in order to satisfy particular purposes. (W. B. Betchart)

2525 Children's Research Center. Analysis of Activity in Emotionally Disturbed Children. A study was conducted to investigate the effects of methylphenidate, thioridazine and placebo on learning in emotionally disturbed children. One dependent measure taken was activity during each testing session. 1800 time is requested to read data punched on paper tape and to have means and standard deviations calculated. (R. L. Sprague)

2529 T Department of Computer Science. Finding Roots in Time-Sharing. PL/I program to process a simplified time-sharing command language to allow a user to find roots of a polynomial. (West)

2530 Civil Engineering. Spatially Varied Open Channel Flow. The purpose of the project is to numerically investigate the various terms in the complete one dimensional, steady, dynamic equation for spatially varied flow so that the implications of additional simplifications can be evaluated. (Yen Wenzel)

2533 Electrical Engineering. Microstrip Line Analysis. Various kinds of microstrip line structures will be analyzed by using a new analytical method. Several data which are useful for the practical design will be obtained. The numerical method involves the inversion of matrix, the solution of transcendental equations, etc. (T. Itoh)

2534 T Health Education. Seniors' Evaluation of the Illinois Driver Education Program. This project is concerned with administering an opinion questionaire to a random sample of high school seniors in the state of Illinois in order to find out what they think of the program they have received. This project is part of a statewide evaluation of Driver Education, both classroom and behind-the-wheel. (F. A. Clark)

2535 T Vocational and Technical Education. A Comparative Study of Undergraduates, Homemaking and Occupational Teachers. A comparative study of undergraduates, homemaking teachers and occupational teachers to ascertain attitudes, knowledges and plans in relation to an employment emphasis in high school home economics. (Bobbitt)

2536 T Business Administration. Multiple Discriminant Analysis of Brand Loyalty. To determine the relative influence of 10-15 demographic and shopping independent variables on brand loyalty in the automobile industry.

To determine the influence of 37 demographic, shopping, and motivational independent variables one at a time on brand loyalty in the automobile industry. (R. M. Hill)

2537 T Physical Education for Men. Leadership Behavior of Physical Education Administrators. A study of leadership behavior of university and junior college physical education administrators. (Gordon A. Olafson)

2538 Institute of Labor and Industrial Relations. Instrumentality. Analysis of the relationships between perceived contingencies, expectancies and performance feedback and role performance within complex interdependent situations. Quantitative analyses include complex correlational and mean difference techniques. (Graen)

2539 T Geography. Regression Analysis for the Prediction of Demand for Nitrogen Fertilizer. This problem is a time-series analysis to predict the level of nitrogen fertilizer use. The major variables are the price of nitrogen, the price of corn/soybeans and a time trend factor. Linear transforms of the data will be used. (Erickson)

2540 Department of Computer Science. Flowchart Generation on Cal-Comp Plotter. Flowchart generation on Cal-Comp Plotter. (J. Thomas)

2541 Mechanical Engineering. Design Workshop. Summer workshop held for non-university personnel in design. (C. S. Larson)

2542 Engineering College and Station. Study of Tree and Graph Algorithms. Development of a list processing language, Nucleol, and its use in the study of tree and graph algorithms, and in transformational grammars. (J. Nievergelt)

2543 Electrical Engineering. Ionospheric Faraday Rotation Measurements. To process Faraday rotation data received from the beacon satellite. (K. C. Yeh)

2544 T Physics. Reactions From Loosely-Bound Elementary Particles. Pion photoproduction from Deuterium is used to investigate the validity of various impulse-factorization models. Comparison is made with the data and with impulse models. The method is generalized to He^3 reactions. (H. R. Hicks)

2545 Mechanical Engineering. Film Cooling. A numerical study of a boundary layer type problem associated with film cooling. The equations to be solved are a set of coupled parabolic partial differential equations. (A. M. Clausing)

2546 Civil Engineering. Oxygen Demand and Re-aeration. Chemical and biochemical oxygen demand in turbulent water can influence the net rate of oxygen absorption from the atmosphere. The computer will be used to evaluate analytical solutions for absorption and diffusion rates and to perform the statistical analysis of laboratory data. (E. Holley)

2547 Civil Engineering. Analysis of Shear Walls. A computer program will be prepared to analyze a multistoried frame with combinations of shear walls using the finite element method of analysis. (A. F. Abbasi)

2548 Classics. APA Summer Institute in Computer Applications to Classical Studies. A six week institute using different programming languages on research on texts in Greek and Latin. (John J. Bateman)

2549 Office of Administrative Studies. Administrative Research. Administrative research related to institutional data. (J. Terwilliger)

2550 T Materials Research Laboratory. Matrix Behavior in Composites at Low Strains. Computation of stresses and strains. (K. Chawla)

2551 Children's Research Center. Analysis of Data From Emotional Disorders Project, Adler Zone Center. There are behavioral observations taken of children who are part of the Emotional Disorders Project. The computer will be used to analyze data produced by the various observations and to score a behavioral checklist. Correlations and analysis of variance are among the statistical procedures used in analyzing the data. (M. McQueen)

2553 Civil Engineering. Measurement of Benthic Oxygen Uptake. The oxygen uptake by the sludges and life forms which make up the stream benthos or bottom layer is often one of the most significant factors affecting stream dissolved oxygen concentrations. The purpose of this study is to develop and test equipment capable of measuring benthic oxygen uptake. The dissolved oxygen in a constant temperature system will be monitored using probes. Correction will be made for oxygen uptake of streamwater by subtracting uptakes of an identical system with no benthic sample. (J. C. Hovious)

2555 T Psychology. A Study of Interpersonal Attraction in the Dating Dyad. Thesis is concerned with the differential effects of various interpersonal attraction theories in the dating situation. The importance of a number of variables in insuring a satisfactory date will also be ascertained. (J. P. Curran)

2556 Psychology. Physiognomic Perception Studies. We are engaged in studying recognition for faces of own and other race. The research involves training procedures which will allow improvement in recognition ability to be examined as a function of the race of the subject, the race of the training stimuli, and the race of the test stimuli. In addition, categories used in describing faces will be related to recognition scores. (R. Malpass)

2558 T Sociology. The Police Sergeant, An Analysis of His Career And Attitudes. The social characteristics and attitude responses of police sergeants will be analyzed as a function of the police sergeant's position in the organizational mileu. Organizational flow charts will be employed with special attention paid to the sergeant's career progression through time and position. SOUPAC will be employed as the programming language. (Robert E. Ford)

2559 T Chemistry. Spherical Fins in Boiling Liquids. Evaluation of spheres as fins in boiling liquids. Thesis on boiling heat transfer. (G. Singh)

2564 T Electrical Engineering. Autocorrelation Studies. Determination of the correlation of various laser outputs with themselves and other lasers under a variety of operating conditions. (R. Uhlhorn)

2569 T Nuclear Engineering. Pumping of Gas Lasers by Nuclear Radiations. Parametric studies of pumping of gas lasers by nuclear radiations: influence of gas pressure, nature of gas, neutron flux, geometry of the laser, etc. (J. C. Guyot)

2570 Electrical Engineering. Modeling A Propagation Medium. An attempt to model a medium from its scattering properties. (D. H. Schaubert)

2571 T Theoretical and Applied Mechanics. Dynamic Calibration of Photoelastic Materials. The computer will be used to fit a Fourier series to sets of force - time data points. These series will be integrated and evaluated to determine dynamic stress - strain relations for various low modulus photoelastic materials. (M. L. Janssen)

2572 T Civil Engineering. Optimum Design of Framed Structures. Development of a general formulation for the optimum design of framed structures. (W. McCutcheon)

2574 T Economics. An Earnings Function for College Graduates. A number of variables, including ability indices, will be regressed on income of college graduates for purposes of estimating the relative contribution of the various factors in explaining variation in income earned by college graduates. (M. Redman)

2575 Political Science. State Legislator - Lobbyist Study. This study is an analysis of interactions between state legislators and lobbyists representing the education associations in four states. Data from the fifty-state data banks compiled by Dye, Grumm, and Zeigler-Johnson will also be used. (K. Johnson)

2576 Geography. SYMAP. Addition of SYMAP program to computer facilities thence to use for mapping sediment classes in alluvial flood plain of Ohio River. (C. Alexander)

2577 Psychology. Simulation of Verbal Discrimination Learning. Paired-Associate data fit by several models of verbal discrimination learning. This involves parameter estimation by means of trial-and-error search of parameter space. Theoretical predictions are computed either by calculation or by simulated experiments. Fitting data by parameter estimation is a method of comparing different models and of testing the assumptions of a particular model. (W. Batchelder)

2579 Civil Engineering. Analysis of Heterogeneous Media. Analysis of a model consisting of a mortar matrix and aggregates using the finite element method. (S. Diaz)

2582 Psychology. Social Reinforcement in Children, and Test Anxiety in Children. Experimetal studies of causes of effects of test anxiety on learning, performance, and personality functioning in children. Other studies investigating the determinants of the effects of different kinds of social reinforcement on children's learning and performance. Several studies on children's achievement expectations. (Kennedy Hill)

2583 Animal Science. Swine Blood Groups. Blood groups of pigs in twelve blood group systems will be analyzed to examine the association between blood groups and other traits. The method of least squares will be used. (B. Rasmusen)

2585 T Education. Pre and Post Test Comparison of Scores to Determine Significance of Change for 4 Groups of Elementary Education Majors. (R. Griffiths)

2586 T Zoology. Bioenergetics of Animals. Experimental studies in the physiology and ecology of animals especially in relation to their energy requirements and tolerance of temperature. (S. Kendeigh)

2587 Children's Research Center. Memory in Retarded Children. One probable cause of the severe deficit in the learning ability of retarded children is that they have a faulty short-term memory. The objective of this research is to investigate the causes of interference in children's short-term memory and see how this relates to intelligence and development. The results should give further scientific information about development procedures and contribute to the training and management of the retarded. (K. Scott)

2588 T Mechanical Engineering. Gear Systems Subjected to Vibrations. Influence of vibrations on gear efficiency. (H. Mamoun)

2589 T Education. Manpower Supply. Frequency counts of training personnel in special education in the United States, correlation of variables with these counts, and multi-variant analysis. (H. Saettler)

2590 Electrical Engineering. Gaseous Electronics. Solution to differential equations associated with the spatial distribution of excited states in a gas discharge. (J. Verdeven)

2595 Home Economics. MMPI Marital Adjustment. Computer research scoring and analysis program for Minnesota Multiphasic Personality Inventory. Comparisons of poorly and well adjusted married couples profiles. (M. Sporakowski)

2596 T Electrical Engineering. Transient Response of LP Antenna. This problem will involve the response of a "broadband" antenna to a very short pulse of energy with the analysis being done in the time domain. (G. Perrine)

2597 Civil Engineering. Dynamic Stability. Study of the stability of a column subjected to a transient thrust via Liapunov's Direct Method. (S. Holzer)

2600 T Physical Education for Men. Physical Fitness and Heart Rate. Exercise research- simple T-test and measures of central tendencies - to determine physiological changes as a function of a prescribed exercise program. (M. Dwyer)

2601 T Physical Education for Men. Effects of Exercise on Body Composition. Exercise Physiology to find out if exercise program will have any effect on the body composition, i.e., amount of fat and muscle cholesterol level. Statistical treatments used; factor analysis, analysis of covariance. (P. Scharr)

2602 Civil Engineering. Proportion Modification Procedures. Study of convergence in sequential application of nonlinear programming, search, and dynamic programming procedures to structural design process. (R. N. Wright)

2603 T Electrical Engineering. Computer Designed Induction Loops. Fields from different types of rectangular induction loops will be calculated and plotted by the computer. (G. Costello)

2604 T Sociology. Social Structure, Psychological Disorganization and Social Isolation. SOUPAC programming will be used to analyze data gathered from an area probability sample of rural heads of households. Statistical analyses include frequency counting, partial correlations, correlations and factor analysis. The particular problem concerns the concomitant variation of social structure, psychological disorganization and social isolation. (L. Seiler)

2605 The Colwell Company. Dump 1130 Disks to Magnetic Tape. Copy 1130 disk packs onto magnetic tape via the 360. (D. Longcor)

2606 T Electrical Engineering. Ultrasonic Absorption in Biological Solutions. Study of the absorption and dispersion of ultrasound in biological solutions. (W. Obrien)

2608 Entomology. Statistical Analysis of Behavioral and Ontogenetic Data. Multiple regression analysis (using SOUPAC) of behavioral and ontogenetic data obtained from experiments with blister beetles (Insecta). (R. Selander)

2609 Entomology. Statistical Analysis of Entomological Data. Statistical analysis of entomological experiments and surveys by members of the faculty of Department of Entomology and their graduate students. SOUPAC will be used. (R. Selander)

2611 T Sociology. Social Class and Adolescent Educational Aspiration. Questionaire data involving a national sample of 10,000 male adolescents are analyzed for the correlates of college aspiration and attendance. The research focus is upon differential correlates within differing socio-economic status groupings. The major intervening variables which are analyzed to account for the differential effects of socio-economic status are parental educational expectations for their sons and the educational aspirations of the adolescents' peer group. (E. Haurek)

2613 Psychology. Conditioning and Attraction. Research on general problems in personality and social psychology. Specifically concerned with testing explanations of the often observed relationship between similarity of personality and attitudes and attraction between people. (G. Clore)

2615 T Department of Computer Science. Simulation of Service Computer Facility. Data on the flow of jobs through the service computer system will be gathered, and a simulation model prepared. The model will then be varied to determine the effect of certain changes on the flow of work through the computer. (H. Adams)

2616 Theoretical and Applied Mechanics. Circle of Willis Hemodynamics. The hemodynamics of the circle of Willis (main distribution center for blood in the brain) is being studied with the aid of computer models. Hydraulic transmission line theory is used to secure variation of fluid impedance with frequency. (M. Clark)

2617 State Geological Survey. Coal Beneficiation. A large amount of data on float-sink characteristics of Illinois coals have been compiled from laboratory procedures. Computations are to be made using these data, as well as statistical analyses of the results. (J. Simon)

2618 Theoretical and Applied Mechanics. Follower Stability Analysis. Study of the static and dynamic stability of a beam loaded by a tangential follower force at an arbitrary point in the span. (J. Wiley)

2619 T Civil Engineering. A Systems Analysis of Local Rural Road Administrative Units in Illinois. The thesis is concerned with an operational and economic analysis of the township and district road system in the state of Illinois. The research includes a descriptive statistical analysis of the system and the development and evaluation of proposed operating procedures. (W. Berg)

2623 T Political Science. Political Alienation, Cabalism and Political Extension. I need the computer time to carry out secondary analysis of survey data to determine the extent to which persons characterized by low political efficacy and high distrust of the federal government tend to adhere to extremist political movements, and/or maintain a cabalist outlook on political events. (S. Bennett)

2624 Sociology. Chicago Policemen. Study of Chicago policewomen exploratory research. (L. Ford)

2625 Finance. Life Insurance Company - Mutual Fund Combination Study. 360 time required to analyze: a) questionnaire data from life insurance company-mutual fund study; b) data for deposit-rate competition studies. (C. Linke)

2626 Education. Junior College Student Study. A panel of junior college students is providing reponses to various questionnaires and indices. These responses will be analyzed to determine the usefulness of various non-cognitive variables in predicting withdrawal or noncontinuance in college. The questionnaires will be examined by submitting responses to item analysis. Discriminate analysis will be used to evaluate ability to differentiate between groups of students. (W. Wellner)

2627 Civil Engineering. This is a request for a permanently assigned spec number for the Layered System Analysis Program on the disk pack. (E. Barenberg)

2628 T Psychology. Semantic Features and Recognition Memory. Students were shown lists of words and were required to identify each word as being either one that was presented before or as a new word in the list. The semantic relationships between words in the list was varied. Recognition of words was predicted to be a function of semantic similarity. (W. Smith)

2630 T Psychology. Drugs and Schizophrenia. Controlled investigation of the withdrawal of maintenance tranquilizers in a group of chronic schizophrenic mental patients. The withdrawal group is put on placebo and compared to 2 match control groups. Each group (drug or placebo) is subdivided into learning and milieu therapy groups. (L. Tobias)

2631 T Electrical Engineering. Electromagnetic Scattering From Two-Dimensional Perfectly Conducting, Arbitrary Shaped Bodies. Calculate the electromagnetic scattering properties of two-dimensional perfectly conducting, arbitrarily shaped scattering bodies. (D. Wilton)

2633 Special Education. Survey Work; Linguistic Analyses. The project is concerned with the analysis of syntactic structure in the written language of profoundly prelingually hearing impaired students within the theoretical framework of transformational-generative grammar. (S. Quigley)

2634 T Chemistry. Crystal Field Calculation. Numerical method to fit the spectrum with parameters. (R. Drago)

2635 Materials Research Lab. Data Processing for Service Analytical Jobs. Data processing for service analytical jobs. (A. Unertl)

2636 T Theoretical and Applied Mechanics. Stress and Deformation of Curved Beams. Time will be used principally to numerically integrate a set of four coupled linear ordinary differential equations of a total of fourteenth order. These equations arise in the solution for the stress and deformation of a curved thin-walled beam. (R. Witzsche)

2637 T Physical Education for Men. Strength-Training. Comparison of 4 different programs; their effects on strength and endurance. (N. Goodban)

2638 T Sociology. Status Inconsistency and Mental Disorder. Survey data from rural Illinois is being analyzed to determine the relative characteristics of several measures of status inconsistency and to determine its correlation with rates of mental disorder. (R. Hough)

2639 T Physics. Transport Coefficients for Ising Model. To calculate transport coefficients for a two-dimensional time-dependant Ising model close to the critical point. (A. Sadig)

2640 Agricultural Economics. Analysis of 100 Ill. Feed Supply Firms as Suppliers of Ag Credit. The study involves the analysis of 100 Illinois feed supply firms and their management of accounts receivable on a cross sectional basis. The statistical analysis will involve frequency counting, matrix transformations, and multiple regression. (J. Hopkin)

2641 Theoretical and Applied Mechanics. Composites. A. Finite element solution of cracks in non-homogeneous materials. B. Stress analysis in three phase fibrous composites by finite element methods. (H. Corten)

2642 Finance. Bank Profitability. My computer requirements are of two sorts: 1) Bank data from Federal Deposit Insurance Corporation must be edited prior to analysis; 2) statistical analysis will involve fitting equations by multiple regression techniques. (W. Bryan)

2643 Education. Thai Universities. The research concerns the sociology of universities and students in Thailand. Social mobility mediated by the universities is examined for several of its aspects, including: rural-urban migration, ethnic assimilation, and class mobility. The research studies the campus culture which emerges among the students and the impact it has on the attitudes of the students. Research is directed also to the investigation of organizational change occurring in the universities in response to technological and other sources of modernization existing in the larger society. (W. Maxwell)

2644 T Nuclear Engineering. Multidimensional Integral Neutron Transport Solutions. Solution of the multidimensional integral neutron transport equation by self-consistent semidirect variational techniques. (H. Stoll)

2646 T Physics. Optical Properties and Band Structure of Semiconductors. The band structure of semiconductors is being studied using modulated reflectance techniques such as electroreflectance and diezoreflectance. (P. Handler)

2647 T Materials Research Lab. Phonon Frequencies of Simple Metals. This is a calculation of the dominant effects of the electron band structure on phonon frequencies in metals. (W. Fehlner)

2648 T Physical Education for Men. Reproduction of Data. Required to pay for reproduction of data deck on 360-20. (G. Olafson)

2651 Mechanical Engineering. Transient Diffusion Flame Phenomena. Data reduction and verification of significant parameters within the envelope described by the diffusion flame for Reynolds and Nusselt Numbers greater than zero. (W. Hull)

2654 Mechanical Engineering. General Problems in Gas Dynamics. General problems in gas dynamics. (W. Chow)

2656 State Water Survey. Hydraulic Geometry of Streams. The research on the hydraulic geometry of streams is a project which aims at a description of the river flow phenomena from the hydraulic point of view. A number of rivers that represent a variety of geographical regions have been selected for the research and the analysis is made for 15 to 40 different points which are distributed throughout the watershed of everyone of the rivers. (R. Sinclair)

2657 T Psychology. Attention, Rules, and Conceptual Shifts. Children 4, 6, and 8 years of age were trained on a simple visual discrimination task and then required to solve a reversal shift. On each trial (for half the Ss) or every third trial (the other half) the child was asked to answer a question about his hypotheses about the task (Which ones are winners? or Which ones are losers?). Other variables manipulated were attention (to relevant or irrelevant dimension or neither) and reinforcement schedule instructions (continuous or probabilistic). Data of interest are prediction of choice responses from rule-statements (single-trial prediction and no-trial prediction) and the % of variance in rule-statements and choice responses accounted for by the experimental variables (age, frequency of questioning,

reinf. expectancy, and attention group). (R. Pratt)

2658 Mechanical Engineering. Diesel Engine Combustion. Analysis of combustion process in a diesel engine. (W. Hull)

2659 T Physical Education for Men. Physical Fitness Changes in a PE Independent Study Program as Compared with Traditional PE at the Secondary Level. Replaces 7094 PS Number 94013. (S. Kittleson)

2660 T Physical Education for Men. Electrocardiographic Measurements. Replaces 7094 PS Number 8Ø005. (D. Allard)

2661 T Physical Education for Men. Effects of Physical Training on Serum Lipids. Replaces 7094 PS Number 85001. (C. Milesis)

2662 T Physical Education for Men. Faculty Research: The Effects of PEM 100 Foundation in the Attitude Toward Physical Activity. Replaces 7094 PS Number 85027. (J. Razor)

2663 T Physical Education for Men. Individual and Group Performance on a Muscular Power Task. Replaces 7094 PS Number 8D008. (D. Landers)

2664 T Physical Education for Men. Analysis of Communication Structure of Univ. Admin. and Instructional Units. Replaces 7094 PS Number 93009. (R. Case)

2665 T Physical Education for Men. Attitude Change Through Cognitive Dissonance. Replaces 7094 PS Number 93016. (N. Al Talib)

2666 T Physical Education for Men. Electrocardiographic Measurements. Replaces 7094 PS Number 93010. (C. Marcil)

2667 T Physical Education for Men. Effects of Basic Movement and Swimming on Physical Fitness of Women. Replaces 7094 PS Number 93027. (J. Babka

2668 State Water Survey. Hydrometeorological Studies. Research studies using dense raingage network data will be done with particular emphasis on the new 196-gage network. We have plans to use this expanded network to make analyses of rain cell characteristics for application in weather modification research and rain physics studies. The data will continue to be employed in studies of sampling requirements for rainfall measurement, the characteristics of severe rainstorms, area-depth relations, and spatial and temporal variability evaluations on larger areas than has been possible before. (R. Sinclair)

2669 State Water Survey. Water Quality Studies. Water quality parameters of Illinois surface and ground water will be studied. The effect of these parameters on the environment will be investigated along with the measures needed to be taken to off-set the pollution's effect on the ecology of the Illinois waters. (R. Sinclair)

2670 State Water Survey. Ground Water Records Analysis. A study of ground water data for various parts of the state of Illinois will be done. The major objective of this research is to study the stationary time series of water levels. (R. Sinclair)

2671 State Water Survey. Study of Watershed Characteristics. This research will involve the study of hydrological watershed characteristics. The main objective is to investigate the interaction of these characteristics. Since the hydrological characteristics are inter-dependent, modeling and statistical techniques will be used frequently throughout this study to gain insight into these relationships. (R. Sinclair)

2672 State Water Survey. Rainfall Analysis. This project will deal with analyzing basic rainfall data of all forms. Elementary studies concerning the characteristics of the raw data will be done. Statistical analyses will be performed in conjunction with the various phases of the project. (R. Sinclair)

9.4 Class Problem Specifications

During the second quarter of 1969, 68 problem specifications were submitted to cover all assigned problems on the System/360 in the following courses.

2429	Civil Engineering 297.
2430	Civil Engineering 230.
2431	Civil Engineering 497.
2432	Civil Engineering 336.
2433	Civil Engineering 338.
2440	Civil Engineering 297.
2441	Business Administration 573.
2443	Chemistry 122.
2444	Chemistry 422.
2448	Mathematics 263.
2455	Animal Science 103.
2456	Physiology 404.
2457	Economics 272.
2462	Electrical Engineering 230.
2463	Industrial Engineering 458.

2470 Nuclear Engineering 441.

2480 Architecture 348.

2492 Agricultural Economics 491.

2496 Business Administration 374.

2499 Electrical Engineering 416.

2507 Political Science 315.

2508 Music 499.

2512 Civil Engineering 297.

2513 Elementary Education 459.

2521 Computer Science 101.

2524 Secondary Education 199.

2526 Nuclear Engineering 495.

2527 Electrical Engineering 497.

2528 Computer Science 101.

2531 Music 343.

2532 Music 443.

2552 Psychology 216.

2554 Aeronautical and Astronautical Engineering 263.

2557 Nuclear Engineering 451.

2560 Mechanical Engineering 264.

2561 Mechanical Engineering 263.

2562 Survey Research Lab 999.

2563 Electrical Engineering 272.

2565 Civil Engineering 262.

2566 Civil Engineering 391.

2567 Educational Psychology 390.

2568 Electrical Engineering 420.

2573 Mechanical Engineering 271.

2578 Mathematics 490.

2580 Civil Engineering 497.

2581 Aeronautical and Astronautical Engineering 391.

2584 Anthropology 355.

2591 Mechanical Engineering 293.

2592 General Engineering 393.

2593 Education 449.

2594 Electrical Engineering 389.

2598 Computer Science 287.

2599 Mechanical Engineering 410.

2607 Marketing 474.

2610 Electrical Engineering 350.

2612 Business Administration 373.

2614 Computer Science 290.

2620 Mechanical Engineering 458.

2621 Electrical Engineering 383.

2622 Computer Science 490.

2629 Accountancy 325.

2632 Computer Science 209.

2645 Electrical Engineering 323.

2649 Special Education 449.

2650 Political Science 305.

2652 Architecture 358.

2653 Political Science 453.

2655 Electrical Engineering 498.

10. IBM 7094/1401 SERVICE, USE, AND DEVELOPMENT

(Supported in part by the National Science Foundation under Grant No. NSF-GP-700.)

10.1 Log Summaries

Table I - IBM 1401-II
Summary of Use
April, 1969

Scheduled Engineering	2:35
Unscheduled Engineering	10:15
Maintenance	5:02
7094 Preparation	369:48
List/Reproduce	11:16
Code Check	:10
Tape Dump	1:24
1604 Preparation	:18
Air Conditioning	17:20
Idle	157:39
Total	575:47

Table II - IBM 1401-II
Summary of Machine Errors
April, 1969

1402 Card Reader Punch	2
1403 Printer	2
729V Tape Drives	1
Total	5

IBM 7094 TABLE III APRIL, 1969

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	IBM 7094 USAGE IN HOURS-MINUTES-SECONDS TANDE[2]	RESEARCH	REFUND	TOTAL
AAE	0	4	4	0	1	1		13 37		13 37
ACCY	0	58	58	0	1	1		33 32		33 32
ADV	0	8	8	0	1	1		10 01		10 01
AGE	0	11	11	0	1	1		4 19		4 19
AGEC	4	89	93	1	7	8	1 04	4 38 28		4 39 32
AGRON	0	3	3	0	1	1		39		39
ANS	0	38	38	0	4	4		1 06 01		1 06 01
ANTH	21	0	21	1	0	1	6 14			6 14
ASTR	0	74	74	0	2	2		1 46 18		1 46 18
BINRES	0	80	80	0	1	1		50 24		50 24
CCSCS	0	7	7	0	1	1		6 43		6 43
CCSOC	0	8	8	0	1	1		4 30		4 30
CE	0	16	16	0	3	3		5 19		5 19
CHE	0	482	482	0	18	18		15 41 32		15 41 32
CRC	0	73	73	0	3	3		2 26 02		2 26 02
DCS	0	3	3	0	1	1		16 22		16 22
DGS	0	4	4	0	1	1		8 02		8 02
DNW	0	3	3	0	1	1		2 27		2 27
DS	0	11	11	0	2	2		2 16		2 16
ECON	6	3	9	1	2	3	16 40	2 52		19 32
ED	119	68	187	2	9	11	3 37 15	1 44 47		5 22 02
EDADM	0	8	8	0	1	1		1 03 54		1 03 54
EDPSY	161	1	162	4	1	5	2 39 56	10		2 40 06
EE	0	21	21	0	3	3		59 44		59 44
ENTOM	0	17	17	0	2	2		11 52		11 52
FIN	0	19	19	0	3	3		12 13		12 13
FOR	0	12	12	0	2	2		15 03		15 03
FT	0	4	4	0	1	1		54		54
GENE	0	2	2	0	1	1		25		25
GSA	0	27	27	0	1	1		16 55		16 55
HEC	0	6	6	0	1	1		4 26		4 26
HLTHSV	0	1	1	0	1	1		5 20		5 20
HONORS	0	3	3	0	1	1		12 39		12 39
HORT	0	5	5	0	1	1		8 34		8 34
ICR	0	253	253	0	3	3		8 24 00		8 24 00

IBM 7094 TABLE III APRIL, 1969 -CONT

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	IBM 7094 USAGE IN HOURS-MINUTES-SECONDS TANDE[2]	RESEARCH	REFUND	TOTAL
IED	0	28	28	0	1	1		2 57 50		2 57 50
ILR	0	40	40	0	3	3		1 23 55		1 23 55
INADM	0	4	4	0	1	1		4 01		4 01
LIBS	0	4	4	0	1	1		1 08		1 08
MATRL	0	243	243	0	10	10		7 14 35		7 14 35
ME	137	421	558	2	9	11	32 48	22 01 06		22 32 54
MMPE	0	34	34	0	1	1		11 56		11 56
MUSIC	2	0	2	1	0	1	2 20			2 20
NHS	0	30	30	0	3	3		1 10 08		1 10 08
NUCE	0	49	49	0	2	2		1 17 41		1 17 41
OIR	0	366	366	0	1	1		4 30 43		4 30 43
PEM	0	108	108	0	8	8		1 07 38		1 07 38
PHYB	0	17	17	0	3	3		12 42		12 42
PHYCS	0	76	76	0	7	7		3 59 51		3 59 51
PHYX	0	847	847	0	10	10		80 24 42		80 24 42
POLS	142	13	155	5	1	6	11 35 43	1 04 08		12 39 51
PROVST	0	2	2	0	1	1		28		28
PSYCH	15	658	673	1	30	31	10 37	15 34 01		15 44 38
REC	0	19	19	0	4	4		1 01 42		1 01 42
SCONS	0	3	3	0	1	1		57		57
SGS	0	41	41	0	2	2		27 57		27 57
SOC	45	108	153	3	6	9	32 15	2 06 27		2 38 42
SOCW	0	15	15	0	1	1		27 18		27 18
SPED	1	0	1	1	0	1	25			25
SRL	0	22	22	0	4	4		37 10		37 10
SWS	0	82	82	0	8	8		1 15 18		1 15 18
VPH	0	4	4	0	1	1		11 24		11 24
VPP	0	12	12	0	1	1		3 39		3 39
VTED	0	8	8	0	2	2		5 09		5 09
ZOOL	0	14	14	0	2	2		5 09		5 09
SUBTOTAL	653	4690	5343	22	207	229	19 35 17	191 39 03		211 13 20
DCSSYS[3]	0	340	340	0	5	5		20 04 42		20 04 42
UADP[4]	0	95	95	0	1	1		2 21 00		2 21 00
XDCS[5]	0	8	8	0	1	1		8 52		8 52
TOTAL	653	5133	5786	22	214	236	19 35 17	214 13 37		233 47 54

1 See list of departmental codes following

3 System Improvement and Modifications

Table I - IBM 7094

Summary of Use

April, 1969

Scheduled Engineering			20:07
Unscheduled Engineering			1:44
Maintenance			1:16
Idle			90:27
Miscellaneous (Operator training, tape rewind, rerun of failing problems)			43:05
Total Use			
Training and Education		19:35	
University Administrative Overhead Use		2:21	
System Improvement and Modifications		20:05	
System Accounting		6:12	
System Updating		:09	
Customer Use			
In System	181:10		
Relinquish	4:17		
Customer Use Total		185:27	
		Total Use	233:49
		Total Time	390:28

Table II - IBM 7094

Summary of Errors

April, 1969

Interrupt Switch		1
	Total	1

Table I - IBM 1401-II

Summary of Use

May, 1969

Scheduled Engineering		5:55
Unscheduled Engineering		15:09
Maintenance		1:58
7094 Preparation		400:06
List/Reproduce		5:05
Tape Dump		1:53
Idle		156:54
	Total	587:00

Table II - IBM 1401-II

Summary of Machine Errors

May, 1969

1401 Main Frame		1
1402 Card Reader Punch		1
1403 Printer		1
	Total	3

Table I - IBM 7094

Summary of Use

May, 1969

Scheduled Engineering			31:49
Unscheduled Engineering			1:20
Maintenance			2:28
Idle			51:42
Miscellaneous (Operator training, tape rewind, rerun of failing problems)			40:59
Total Use			
Training and Education		17:07	
University Administrative Overhead Use		5:00	
System Improvement and Modifications		23:47	
System Accounting		9:03	
System Updating		:06	
Customer Use			
In System	207:29		
Relinquish	1:00		
Customer Use Total		208:29	
Total Use			263:32
Total Time			391:50

Table II - IBM 7094

Summary of Errors

May, 1969

Printer	1
Total	1

IBM 7094 TABLE III MAY, 1969

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	IBM 7094 USAGE IN HOURS-MINUTES-SECONDS TANDE[2]	RESEARCH	REFUND	TOTAL
AAE	0	6	6	0	1	1		7 19		7 19
ACCY	0	28	28	0	1	1		20 13		20 13
ADV	0	6	6	0	1	1		3 00		3 00
AGE	0	13	13	0	1	1		23 24		23 24
AGEC	21	93	114	1	7	8	4 22	3 18 51		3 23 13
ANS	0	91	91	0	6	6		41 19		41 19
ANTH	10	0	10	1	0	1	4 44			4 44
ASTR	0	53	53	0	3	3		2 22 11		2 22 11
BINRES	0	69	69	0	2	2		1 40 36		1 40 36
CCSCS	0	6	6	0	1	1		7 37		7 37
CE	0	14	14	0	1	1		4 30		4 30
CFE	0	372	372	0	20	20		19 44 33		19 44 33
CRC	0	115	115	0	3	3		3 12 49		3 12 49
DCS	0	7	7	0	1	1		2 27		2 27
DS	0	3	3	0	1	1		50		50
ECCN	15	26	41	1	1	2	56 01	9 54		1 04 55
ED	111	125	236	2	12	14	4 46 01	3 17 34		8 03 35
EDPSY	71	1	72	3	1	4	2 00 28	14		2 00 42
EE	0	74	74	0	4	4		1 46 28		1 46 28
ENTOM	0	7	7	0	2	2		7 00		7 00
FIN	0	19	19	0	2	2		34 33		34 33
GENE	0	6	6	0	2	2		2 48		2 48
GEOL	0	1	1	0	1	1		43		43
HEC	0	2	2	0	1	1		39		39
HED	0	30	30	0	1	1		33 43		33 43
HONORS	0	3	3	0	1	1		4 12		4 12
HORT	0	3	3	0	1	1		2 52		2 52
IGR	0	172	172	0	2	2		3 42 21		3 42 21
IED	0	19	19	0	1	1		2 19 30		2 19 30
I&LDMH	0	3	3	0	1	1		3 14		3 14
ILR	0	39	39	0	1	1		33 50		33 50
IREC	0	4	4	0	1	1		28		28
LIBS	0	12	12	0	2	2		34 26		34 26
MATRL	0	200	200	0	9	9		12 45 26		12 45 26
MCBIO	0	9	9	0	1	1		2 13		2 13

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	IBM 7094 USAGE IN HOURS-MINUTES-SECONDS TANDE[2]	RESEARCH	REFUND	TOTAL
ME	164	529	693	2	8	10	41 41	21 20 17		22 01 58
MPPE	0	14	14	0	1	1		4 04		4 04
MUSIC	14	0	14	1	0	1	4 40			4 40
NPS	0	10	10	0	1	1		26 13		26 13
NUCE	0	99	99	0	8	8		2 05 28		2 05 28
OIR	0	656	656	0	1	1		12 25 01		12 25 01
ORME	0	5	5	0	1	1		1 08		1 08
PEM	0	54	54	0	8	8		34 38		34 38
PHYB	0	17	17	0	4	4		3 03		3 03
PHYCS	0	78	78	0	8	8		3 27 50		3 27 50
PHYX	0	1166	1166	0	10	10		92 57 43		92 57 43
PCLS	55	4	59	4	1	5	2 36 26	19 33		2 56 59
PROVST	0	80	80	0	2	2		1 55 18		1 55 18
PSYCH	206	725	931	2	26	28	3 18 21	13 11 51		16 30 12
REC	0	8	8	0	2	2		1 58		1 58
SCONS	0	3	3	0	1	1		1 44		1 44
SGS	0	8	8	0	2	2		1 51		1 51
SCC	194	125	319	3	7	10	2 36 25	6 18 11		8 54 36
SPCH	0	14	14	0	1	1		22 19		22 19
SRL	0	27	27	0	4	4		1 39 38		1 39 38
SWS	0	63	63	0	6	6		44 11		44 11
VPH	0	3	3	0	1	1		2 38		2 38
VPP	0	13	13	0	1	1		4 26		4 26
VTED	0	28	28	0	2	2		27 20		27 20
ZOOL	0	2	2	0	1	1		2 24		2 24
SUBTOTAL	861	5362	6223	20	203	223	17 07 09	217 30 34		234 37 43
CCSSYS[3]	0	355	355	0	6	6		23 47 18		23 47 18
UADP[4]	0	80	80	0	1	1		4 59 56		4 59 56
XCCS[5]	0	19	19	0	1	1		5 42		5 42
SUBTOTAL	0	454	454	0	8	8	17 07 09	28 47 14		28 47 14
TOTALS	861	5816	6677	20	211	231	17 07 09	246 23 30		263 30 39

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 University Administrative Overhead Use
5 System Updating

Table I - IBM 1401-II

Summary of Use

June, 1969

Unscheduled Engineering		1:20
Maintenance		3:44
7094 Preparation		472:08
List/Reproduce		5:16
Tape Dump		1:04
1604 Preparation		:24
Idle		75:51
	Total	559:47

Table II - IBM 1401-II

Summary of Machine Errors

June, 1969

1403 Printer		1
	Total	1

Table I - IBM 7094

Summary of Use

June, 1969

Scheduled Engineering			11:37
Maintenance			1:24
Idle			49:41
Air Conditioning			39:00
Miscellaneous (Operator training, tape rewind, rerun of failing problems)			70:11
Total Use			
Training and Education		9:02	
University Administrative Overhead Use		2:29	
System Improvement and Modifications		41:15	
System Accounting		20:02	
System Updating		:06	
Customer Use			
In System	213:40		
Customer Use Total		213:40	
	Total Use		286:34
	Total Time		458:27

Table II - IBM 7094

Summary of Errors

June, 1969

There were no errors during June, 1969.

IBM 7094 TABLE III JUNE, 1969

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	IBM 7094 USAGE IN HOURS-MINUTES-SECONDS TANDE[2]	RESEARCH	REFUND	TOTAL
AAE	0	1	1	0	1	1		1 33		1 33
ACCY	0	35	35	0	1	1		24 32		24 32
ADV	0	4	4	0	2	2		18 03		18 03
AGEC	5	52	57	1	5	6	1 22	2 04 27		2 05 49
AGRON	0	2	2	0	1	1		1 55		1 55
ANS	0	65	65	0	4	4		2 36 13		2 36 13
ANTH	33	0	33	1	0	1	2 00 14			2 00 14
ASTR	0	70	70	0	3	3		7 02 37		7 02 37
ASTRMI	0	18	18	0	1	1		2 25 48		2 25 48
BINRES	0	35	35	0	2	2		1 06 31		1 06 31
CCSCS	0	5	5	0	1	1		6 43		6 43
CE	0	4	4	0	1	1		1 55		1 55
CHE	0	414	414	0	15	15		23 14 23		23 14 23
CRC	0	86	86	0	4	4		2 37 36		2 37 36
DCS	0	4	4	0	1	1		10 37		10 37
DS	0	1	1	0	1	1		21		21
ED	0	338	338	0	12	12		8 14 37		8 14 37
EE	0	75	75	0	4	4		3 19 24		3 19 24
ENTOM	0	9	9	0	2	2		11 05		11 05
FIN	0	13	13	0	1	1		9 39		9 39
GENE	0	27	27	0	2	2		27 10		27 10
GSA	0	1	1	0	1	1		07		07
HED	0	55	55	0	1	1		1 33 57		1 33 57
HLTHSV	0	3	3	0	1	1		27 32		27 32
HORT	0	3	3	0	1	1		1 01		1 01
ICR	0	84	84	0	3	3		4 06 43		4 06 43
IED	0	72	72	0	1	1		1 33 32		1 33 32
ILLDMH	0	4	4	0	1	1		26 42		26 42
ILR	0	55	55	0	2	2		1 47 19		1 47 19
LIBS	0	12	12	0	1	1		42 57		42 57
MATH	0	5	5	0	1	1		12 28		12 28
MATRL	0	124	124	0	11	11		7 39 33		7 39 33
MCBIO	0	3	3	0	1	1		1 19		1 19
ME	200	294	494	2	8	10	4 43 25	6 35 34		11 18 59
MMPE	0	16	16	0	1	1		4 44		4 44

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	IBM 7094 USAGE IN HOURS-MINUTES-SECONDS TANDE[2]	RESEARCH	REFUND	TOTAL
MUSIC	13	0	13	1	0	1	8 27			8 27
NHS	0	13	13	0	3	3		24 06		24 06
NUCE	0	118	118	0	6	6		6 09 25		6 09 25
CIR	0	191	191	0	1	1		6 17 56		6 17 56
PEM	0	170	170	0	11	11		2 38 25		2 38 25
PHYB	0	30	30	0	3	3		1 09 53		1 09 53
PHYCS	0	51	51	0	3	3		4 46 39		4 46 39
PHYX	0	1171	1171	0	11	11		75 53 55		75 53 55
PCLS	35	24	59	2	2	4	2 01 58	1 33 46		3 35 44
PROVST	0	79	79	0	2	2		56 38		56 38
PSYCH	0	988	988	0	30	30		19 06 01		19 06 01
REC	0	18	18	0	3	3		52 32		52 32
SCONS	0	2	2	0	1	1		36		36
SOC	2	338	340	1	8	9	6 25	23 31 34		23 37 59
SOCW	0	7	7	0	1	1		27 21		27 21
SPCH	0	16	16	0	1	1		1 48		1 48
SPED	0	125	125	0	3	3		3 01 22		3 01 22
SRL	0	57	57	0	4	4		5 21 48		5 21 48
SWS	0	38	38	0	5	5		22 43		22 43
VMS	0	7	7	0	1	1		33 18		33 18
VPP	0	1	1	0	1	1		10		10
VTED	0	9	9	0	1	1		7 40		7 40
ZOOL	0	50	50	0	2	2		34 37		34 37
SUBTOTAL	288	5492	5780	8	201	209	9 01 51	233 40 50		242 42 41
DCSSYS[3]	0	564	564	0	6	6		41 14 42		41 14 42
UADP[4]	0	50	50	0	1	1		2 29 24		2 29 24
XDCS[5]	0	14	14	0	1	1		5 49		5 49
SUBTOTAL	0	628	628	0	8	8		43 49 55		43 49 55
TOTALS	288	6120	6408	8	209	217	9 01 51	277 30 45		286 32 36

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 University Administrative Overhead Use
5 System Updating

7094 TABLE III 2ND QT. 1969

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	7094 USAGE IN HOURS-MINUTES TANDE[2]	RES	TOTAL
AAE	0	11	11	0	3	3	0.0	22.4	22.4
ACCY	0	121	121	0	3	3	0.0	1 18.2	1 18.2
ADV	0	18	18	0	4	4	0.0	31.0	31.0
AGE	0	24	24	0	2	2	0.0	27.7	27.7
AGEC	30	234	264	3	19	22	6.8	10 1.9	10 8.7
AGRON	0	5	5	0	2	2	0.0	2.5	2.5
ANS	0	194	194	0	14	14	0.0	4 23.6	4 23.6
ANTH	64	0	64	3	0	3	2 11.2	0.0	2 11.2
ASTR	0	197	197	0	8	8	0.0	11 11.1	11 11.1
ASTRM	0	18	18	0	1	1	0.0	2 25.7	2 25.7
BINRE	0	184	184	0	5	5	0.0	3 37.5	3 37.5
CCSCS	0	18	18	0	3	3	0.0	21.0	21.0
CCSOC	0	8	8	0	1	1	0.0	4.4	4.4
CE	0	34	34	0	5	5	0.0	11.7	11.7
CHE	0	1268	1268	0	53	53	0.0	53 40.7	58 40.7
CRC	0	274	274	0	10	10	0.0	8 18.4	8 18.4
DCS	0	14	14	0	3	3	0.0	29.4	29.4
DGS	0	4	4	0	1	1	0.0	8.0	8.0
DNW	0	3	3	0	1	1	0.0	2.4	2.4
DS	0	15	15	0	4	4	0.0	3.4	3.4
ECON	21	29	50	2	3	5	1 11.6	12.7	1 24.4
ED	230	531	761	4	33	37	8 23.2	13 17.1	21 40.4
EDADM	0	8	8	0	1	1	0.0	1 3.8	1 3.8
EDPSY	232	2	234	7	2	9	4 40.4	0.4	4 40.8
EE	0	170	170	0	11	11	0.0	5 5.6	6 5.6
ENTOM	0	33	33	0	6	6	0.0	29.9	29.9
FIN	0	51	51	0	6	6	0.0	56.4	56.4
FOR	0	12	12	0	2	2	0.0	15.0	15.0
FT	0	4	4	0	1	1	0.0	0.8	0.8
GENE	0	35	35	0	5	5	0.0	30.4	30.4
GEOL	0	1	1	0	1	1	0.0	0.7	0.7
GSA	0	28	28	0	2	2	0.0	17.0	17.0
HEC	0	8	8	0	2	2	0.0	5.0	5.0
HED	0	85	85	0	2	2	0.0	2 7.6	2 7.6

7094 TABLE III 2ND QT. 1969- CONT

DEPT[1]	NUMBER OF RUNS TANDE[2]	RES	TOTAL	NUMBER OF SPECS TANDE[2]	RES	TOTAL	7094 USAGE IN HOURS-MINUTES TANDE[2]	RES	TOTAL
HLTHS	0	4	4	0	2	2	0.0	32.8	32.8
HONOR	0	6	6	0	2	2	0.0	16.8	16.8
HORT	0	11	11	0	3	3	0.0	12.4	12.4
ICR	0	509	509	0	8	8	0.0	15 13.0	15 13.0
IED	0	119	119	0	3	3	0.0	5 50.8	6 50.8
ILLDM	0	7	7	0	2	2	0.0	29.9	29.9
ILR	0	134	134	0	6	6	0.0	3 45.1	3 45.1
INADM	0	4	4	0	1	1	0.0	4.0	4.0
IREC	0	4	4	0	1	1	0.0	0.4	0.4
LIBS	0	28	28	0	4	4	0.0	1 18.5	1 18.5
MATH	0	5	5	0	1	1	0.0	12.4	12.4
MATRL	0	567	567	0	30	30	0.0	27 39.7	27 39.7
MCBIO	0	12	12	0	2	2	0.0	3.5	3.5
ME	501	1244	1745	6	25	31	5 57.9	49 56.0	55 54.0
MMPE	0	64	64	0	3	3	0.0	20.7	20.7
MUSIC	29	0	29	3	0	3	15.4	0.0	15.4
NHS	0	53	53	0	7	7	0.0	2 0.4	2 0.4
NUCE	0	266	266	0	16	16	0.0	9 32.6	9 32.6
OIR	0	1213	1213	0	3	3	0.0	23 13.6	23 13.6
ORME	0	5	5	0	1	1	0.0	1.1	1.1
PEM	0	332	332	0	27	27	0.0	4 20.8	4 20.8
PHYB	0	64	64	0	10	10	0.0	1 25.6	1 25.6
PHYCS	0	205	205	0	18	18	0.0	12 14.4	12 14.4
PHYX	0	3184	3184	0	31	31	0.0	249 16.5	249 16.5
POLS	232	41	273	11	4	15	16 13.1	2 57.4	19 10.6
PROVS	0	161	161	0	5	5	0.0	2 52.4	2 52.4
PSYCH	221	2371	2592	3	86	89	3 28.9	47 52.4	51 21.4
REC	0	45	45	0	9	9	0.0	1 56.2	1 56.2
SCONS	0	8	8	0	3	3	0.0	3.2	3.2
SGS	0	49	49	0	4	4	0.0	29.8	29.8
SOC	241	571	812	7	21	28	3 15.1	31 56.3	35 11.4
SOCW	0	22	22	0	2	2	0.0	54.6	54.6
SPCH	0	30	30	0	2	2	0.0	24.1	24.1
SPED	1	125	126	1	3	4	0.4	3 1.3	3 1.7
SRL	0	106	106	0	12	12	0.0	7 38.6	7 38.6

7094 TABLE II 2ND QT. 1969- CONT

DEPT[1]	NUMBER OF RUNS			NUMBER OF SPECS			7094 USAGE IN HOURS-MINUTES		
	TANDE[2]	RES	TOTAL	TANDE[2]	RES	TOTAL	TANDE[2]	RES	TOTAL
SWS	0	183	183	0	19	19	0.0	2 22.3	2 22.3
VMS	0	7	7	0	1	1	0.0	33.2	33.2
VPH	0	7	7	0	2	2	0.0	14.0	14.0
VPP	0	26	26	0	3	3	0.0	8.2	8.2
VTED	0	45	45	0	5	5	0.0	40.1	40.1
ZOOL	0	66	66	0	5	5	0.0	42.1	42.1
SUBTOTAL	1802	15544	17346	50	611	661	45 44.6	637 53.6	688 38.2
DCSSYS[3]	0	1259	1259	0	17	17	0.0	85 6.8	85 6.8
UADP[4]	0	225	225	0	3	3	0.0	9 50.3	9 50.3
XDCS[5]	0	41	41	0	3	3	0.0	20.3	20.3
TOTALS	1802	17069	18871	50	634	684	45 44.6	733 11.0	783 55.6

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 University Administrative Overhead Use
5 System Updating

10.2 Research Problem Specifications

During the second quarter of 1969, 41 problem specifications were submitted to the Department for computation on the 7094, The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

3387-94001 T Psychology. Prediction of Small Group Performance. Looking at the effects of problem-solving strategies on the predictability of group performance using member abilities as the predictors. (Shiflett)

3388-94002 Survey Research Laboratory. Data Cleaning. Using SSUPAC to secure frequency counts. (Przbylski)

3389-94003 Education. Adrenal Cortical Function in Human Epileptics. A study of adrenal Cortical Function as measured by Eosinophyl and 17 Ketosteroid counts taken 3 times daily over a six week period. The subjects were 6 male and 6 female epileptics who were patients in a mental institution. The study intends to show the relationships between the adrenal cortical function and the pattern of seizures. (William Hurder)

3390-94004 Education. Factor Analytic Studies of State School Systems. This project is a factor analysis of a large number of variables on local school districts within five states: Utah, Idaho, Illinois, Florida, and Kansas. The variables consist of measures on instructional programs, teaching and non-teaching staff, pupil characteristics, financial characteristics of the districts, structure of expenditures, and community characteristics. The problem involves obtaining least squares solution of these variables; and the application of factor analysis to identify a set of variables which best describe the characteristics of school systems within states. Also the problem involves using methods of discriminant analysis to identify variables which best describe common characteristics among states. The data were obtained from field surveys; state school reports; and U.S. Bureau of the Census. (W.P. McLure)

3391-94005 T Chicago Circle Sociology. Life Satisfaction and the Older Person. Three-way analysis of variance of original data, 40 cases. If needed, we would like to run a partial correlation program also. Both of these analyses would be run on several different combinations of cases that are over-lapping groups. A more detailed description will follow, with the data cards. (Ann Smith)

3392-94006 Economics. Contingency Tables. Determination of measures of association between attributes and growth rates of firms. (Eliezer Ayal)

3393-94007 Library Science. Children's Reading and Preferences. Multiple regression correlation between proportion of preference statements supported by current reading and factors of sex, distance, type of library facility in school, and face to face contact programs involving sample and public library personnel; the purpose being to judge the relative importance of these factors for purposes of further investigation. (McClure)

3394-94008 Physics. Porthos Fortran IV Development. Development, modification and debugging of the Porthos Fortran IV Compiler. (Kremers)

3395-94009 T Sociology. Status Discrepancy and Deviant Behavior. The relationship between Status Discrepancy and various forms of deviant behavior (political, religious, mental illness) and the holding of deviant attitudes (anomie, community satisfaction, attitude toward labor unions, big business, etc.) is being explored. Data for over a thousand heads-of-household in a rapidly industrializing rural area in Illinois are being utilized. Several different measures of "status discrepancy" are being compared as well as the relative merit of status discrepancy as a predictive structural variable. (Richard L. Hough)

3396-94011 T Education. Group Effectiveness - Group Processes. Relating administrative effectiveness in the use of group processes and clarity of goals in Illinois Junior Colleges. (L.L. Burden)

3397-94012 T Education. Negotiability Priorities Among Teachers, Union Delegates, and Principals. Determining difference in perceptions of negotiability of items among teachers, union delegates, and principals in selected schools in Illinois. (Tom Plain)

3398-94013 T Physical Education for Men. Physical Fitness Changes in a PE Independent Study Program as Compared with Traditional PE at the Secondary Level. Analysis of variance to determine physical fitness changes in a PE independent study program as compared with traditional PE at the secondary level. (Sherwin Kittleson)

3399-94014 Animal Science. Sensitivity To Cortisone as a Genetic Character of Mice. Several strains of inbred mice have been mated in various ways and treated with cortisone to study the genetics of response to cortisone as evidenced by cleft lip, cleft palate, and resorption. (B. M. Francis)

3400-94015 Animal Science. Gilt Breeding Study. To determine the effect of breeding weight of gilts (female swine) on litter size at birth (total pigs and live pigs) and at weaning (pig age at 21 days) as well as on average wt. of pigs at birth and at weaning. These data are to be corrected for several variables that may influence the results. (D. H. Baker)

3401-94016 T Physical Education for Men. Electromyographical and Anenatographical Analysis of Throwing. An analysis of the similarities and differences of three different skill levels in the overhand and underhand throw for speed. (Deutsch)

3402-94017 Zoology. Relationship Between Ovary Size and Development Time in Drosophila. Two-way selection for ovary size (number of egg tubes) has been carried out for 25 generations of the fruit fly, Drosophila melanogaster. We wish to compare the lengths of the embryonic, larval and pupal periods of development of both sexes of both selected lines, and to examine the regression of development time on ovary size in the females of both lines. The computer will be used to calculate sample statistics and to perform t tests and correlation and regression analyses. (E. H. Brown)

3403-94018 T Education. Job Selection Factors as Related to Predominantly Black and Predominantly White Work Settings. Factor analysis - Job selection factors. Correlation: anticipated racial setting (B and W) and responses to job factors (+ and -). Correlation: students at college (B and W). Relationship between racial composition of college and anticipated racial worksetting. (Jessica Daniel)

3404-95001 T Economics. Decatur Neighborhood Movement Analysis. Statistical analysis on the movement of persons within a neighborhood and neighborhoods within the environs of Decatur, Illinois. (Joyce Linne)

3405-95002 T Special Education. Manpower Supply. Frequency counts of training personnel in special education in the United States and correlation of variables which account for variations in geographical patterns of training. (Herman Saettler)

3406-95003 Animal Science. Growth Study of Swine Lens Nitrogen. Lens nitrogen increases throughout life in mammals. Its relation to age is being studied in relation to breed, sex, and dietary nitrogen intake. (R. G. Kaufman)

3407-95004 T Psychology. Acceleration of Infant's Looking Response. Older infants tend to prefer more complex patterns than younger ones. The purpose of this study is, by providing optimal levels of home stimulation, to have infants look at more complex patterns in a test situation than they would if they did not receive this home stimulation. Three groups of infants received different visual stimulation at eight through twelve weeks and were tested at eight, ten and twelve weeks of age with patterns of varying complexity. (David Greenberg)

3408-95005 Special Education. Analysis of Research On Learning Disabilities Children. A study was conducted on grade school children with learning disabilities in special programs. The resulting data is to be factor analyzed and then factor scores are to be derived for each child. These scores will then be tested for significant differences between various groups. (Ira Langston)

3409-95006 T Veterinary Medical Science. TFEC Project. Five groups of animals (6 in each group) were subjected to treatments, e.e., 1-6 control, 7-12 with MY301, 13-18 ÷ MY301 + Dip Sod., 19-24: MY301 + DP + TFEC, 25-30 TFEC alone - thus forming a CRD with factorials. Analysis of variance for various treatment is desired. Samples were collected at 10 minute intervals for 90 minutes. There are 14 dependable variables for analysis. (H. J. Hardenbrook)

3410-95008 Agricultural Economics. Analysis of Chicago Shell Egg Market. This is an analysis of the Chicago Shell Egg Futures and cash market. It is associated with determining factors important in price determinations and how they change over time. (J. R. Roush)

3411-95009 T Education. Student Characteristics Inventory. Comparative frequency of a variety of student characteristics in different high schools. (Cox)

3412-95010 T Political Science. Attitudes Associated With Student Activism. Frequency counts and measures of statistical association between scaled attitude and social background variables. (Flerlage)

3413-95011 T Special Education. Utilization of Federal Aid. A study of the use of funds under P.L. 85-926 for the preparation of personnel for the handicapped. (Charles Horn)

3414-95012 Institute of Communications Research. Human Judgment. The present studies investigate the parameters of human judgments across a variety of situations. In particular, the variables of interest are: (a) the trans-situational generality of preference and similarity judgments; (b) the subject correlates of such judgments; and (c) the isolation and prediction of individual differences in judgment types. Multivariate methods of analysis will be used including factor analysis, multidimensional scaling, canonical correlation, discriminant function analysis and multi-variate analysis of variance. (Wiggins)

3415-95013 T Physical Education for Men. Effects of Intramural Basketball Participation on Group Cohesion Level. A factorial analysis of the effects on the group cohesion level of success and failure. The relative group cohesion level of 1,300 intramural basketball participants was determined by means of a pre- and post- test. The two independent variables used in the problem are the housing unit and performance as dichotomized into success and failure. (James Peterson)

3416-95014 State of Illinois Department of Mental Health. Evaluation of Our Mental Health Staff's Activities. This problem includes an evaluation of Sub zone 5 mental health staff's time, activities, and programs at the Adler Zone Center. We are concerned with how much time we spend on our various programs, what we do to spend our time (what kind of activities), and with whom we participate in these activities (which community agencies and organization) in regards to individual programs. (Norma Richards)

3417-95015 T Psychology. A Study of Reinforcement Schedules In Social Reinforcement Studies. 110 Ss were included in a two parts study. Each part had a 5 x 2 factorial design. Ss within each experimental design were assigned to one of five different schedules of reinforcement. The sex of S was also introduced as a separate factor. The dependent variables include various persistent and rate measures at a marble dropping task. In addition to 2 way anovas and repeated measures anovas, there is an interest in various correlations between S's variables and the experimental variables and between the various dependent variables themselves. (M. Rosenbaum)

3418-95016 T Agricultural Economics. Generation of Random Numbers From Standard Distribution. Generation of random numbers from normal probability distributions using a SSUPAC program. These numbers are required as input for further calculation using the 360 system. (R. L. Batterham)

3419-95017 Bureau of Economic and Business Research. Forecasting U.S. Economy. The purpose of this project is to forecast the U.S. economy using various economic indicators and aggregate economic data.

A phase of the research necessitates the use of stepwise regression, k-class estimators, and other statistical techniques available and in good working condition on the 7094 SSUPAC. Only a few runs will be necessary. (Bassie)

3420-95018 Animal Science. Intermittent Diethylstilbestrol Treatment of Lambs. Results have been obtained which indicate that the majority of the growth-stimulatory effect of diethylstilbestrol (DES) in lambs may occur during the first 3 to 4 weeks of DES treatment. After that time continued treatment with DES may result in no further beneficial effects. This experiment tests the effect of continuous DES administration, intermittent DES administration, and no DES administration on nitrogen balance and plasma urea nitrogen of lambs. SSUPAC will be used for the statistical analysis of data obtained from this study. (U. S. Garrigus)

3421-96001 Recreation. Leisure and Recreation Studies. This project includes analysis of questionnaire data concerning correctional institutions' recreation programs. Frequency count, means, standard deviations and correlations are the principal statistical data analysis techniques. (A. Caskey)

3422-96002 Education. Independent Study for Graduate Credit. Pre-posed study of attitudes of senior elementary education students to peer evaluation techniques. (Auger)

3423-96003 T Physical Education for Men. Prediction of Peak Oxygen Intake From Selected Fitness Variables. Multiple regression equation for the prediction of peak oxygen intake. Test-retest reliability coefficient of correlation. (H. Bergtholdt)

3424-96004 T Education. Vocational Interests of Children. Analysis of vocational interests of children. Utilization of Havighurst's Developmental Task for preference indication. (C. Burden)

3425-96005 Psychology. Factors Affecting Children's Oddity Problem Solving. An analysis of the role of overtraining and dimensional dominance on transfer performance (IDand ED shifts) in children's dimension abstracted oddity learning. (A. Brown)

3426-96006 T Psychology. Attention, Rules, and Conceptual Shifts. A series of 2 x 2 x 3 x 3 Fixed Model Analyses of Variance. About 16 ANOVAS (16 dependent variables). Also a series of Pearson Product-moment correlations. In addition, computation of $omega^2$ and rho^2 for the above analyses.

3427-96007 T Psychology. Drugs and Schizophrenia. This is a controlled investigation of the effects of withdrawal of maintenance tranquilizers in a group of chronic schizophrenic mental patients. The withdrawal group is put on placebo and compared to 2 matched control groups. Each group (drug or placebo) is subdivided into learning and milieu therapy groups. (L. Tobias)

10.3 Class Problem Specifications

During the second quarter of 1969, 3 problem specifications were submitted to cover all assigned problems on the 7094 in the following courses.

J998-94010 Sociology 185.

J999-94019 Political Science 426.

J1000-95007 Psychology 332.

11. GENERAL DEPARTMENT INFORMATION

11.1 Personnel

The number of people associated with the Department in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	24	2	25.3
Visiting Faculty	2	-	2.0
Research Associates	4	-	4.0
Graduate Research Assistants	12	104	65.65
Graduate Teaching Assistants	-	11	4.84
Professional Personnel	31	3	33.17
Administrative and Clerical	29	-	29.00
Nonacademic Personnel (Monthly)	67	-	67.00
Nonacademic Personnel (Hourly)	5	71	46.50
Total	174	191	277.46

The Department Advisory Committee consists of Professor J. R. Pasta, Head of the Department; Professor J. N. Snyder, Associate Head of the Department, Professors K. W. Dickman, M. Faiman, L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J. Nievergelt, R. S. Northcote, J. R. Phillips, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, P. E. Saylor, and D. L. Slotnick.

11.2 Bibliography

During the second quarter, the following publications were issued by the Laboratory:

File Numbers

(1) Graham, Marvin L., "The Role of Input/Output in a Computer System," File No. 800, June 27, 1969.

(2) Grossman, Gary R. and Scafe, Douglas L., "SSK/SSK Reference Manual," File No. 798, June 13, 1969.

(3) Lewis, George T., "Specifications for Termi-Point Wiring of Section 32B (Descrete Beam Motion Logic) of the Illiac III Computer System," File No. 550-128, April 16, 1969.

(4) McCormick, Bruce H., "Illiac III Bibliography Condensed Listing," File No. 797, April 30, 1969.

(5) Schwebel, John C. and McCormick, Bruce H., "Analysis of Simple Line Drawings Statement of the Problem," File No. 796, April 11, 1969.

(6) Wallman, Lawrence, "Specifications for Lenticular Screen," File No. 550-129, May 28, 1969.

(7) Wallman, Lawrence, "Specifications for Special Cathode Ray Tube,"File No. 550-130, May 28, 1969.

(8) Wallman, Lawrence, "Specifications for Special Cathode Ray Tube and a Lenticular Screen," File No. 550-131, May 28, 1969.

(9) Winje, Gilbert L., "Random Number Generators for Illiac IV," File No. 799, June 20, 1969.

Report Numbers

(1) Abel, Norma, Budnik, Paul, Kuck, David, Muraoka, Yoichi, Northcote, Robert, and Wilhelmson, Robert, "TRANQUIL: A Language for an Array Processing Computer," Report No. 315, April 1, 1969.

(2) Atkins, Daniel, "Design of the Arithmetic Units of Illiac III: Use of Redundancy and Higher Radix Methods," Report No. 333, May, 1969.

(3) Borovec, Richard, "The Pattern Articulation Unit of Illiac III Implementation of the Homogeneous Instruction 'BOOLE'," Report No. 338, June 20, 1969.

(4) Carter, C., Lopeman, H., Miller, R., and Whaley, A., "DEC PDP-7 Interface to IBM 2701-PDA," Report No. 323, April, 1969.

(5) Divilbiss, J., "Illiac III Scanner Analog Circuits," Report No. 320, April 10, 1969.

(6) Gear, C., "An Interactive Graphic Modeling System," Report No. 318, April 7, 1969.

(7) Henderson, D., and Gold, D., "Suggestions for Use of a Particular Directory Scheme," Report No. 321, April 10, 1969.

(8) Michel, M., "User Programming Specifications for the PDP8/360 Communications System," Report No. 317, April, 1969.

(9) Nievergelt, J., Fischer, F., Irland, M., and Sidlo, J., "NUCLEOL - A Minimal List Processor," Report No. 324, April, 1969.

(10) Pasta, J., "The Role of the University in the Computer Age," Report No. 330, May 20, 1969.

Theses

(1) Casasent, David, "An On-Line Electro-Optical Video Processing System," (Ph.D.), Report No. 331, May, 1969.

(2) Chelin, Hartley, "An Analog-to-Digital Conversion Supervisor for the IBM 1800," (M.S.), Report No. 337, June, 1969.

(3) Esch, John, "RASCEL - A Programmable Analog Computer Based on A Regular Array of Stochastic Computing Element Logic," (Ph.D.), Report No. 332, June, 1969.

(4) Gaffney, John, "TACOS: A Table Driven Compiler-Compiler System," (M.S.), Report No. 325, June, 1969.

(5) Gold, David, "A Model for Linear Programming Optimization of I/O-Bound Programs," (M.S.), Report No. 340, June, 1969.

(6) Lawrie, Duncan, "GLYPNIR - A List Processing Language for Illiac IV," (M.S.), Report No. 322, April 1, 1969.

(7) Matsushita, Yutaka, "A Solution to the Hidden Line Problem," (M.S.), Report No. 335, June 1, 1969.

(8) McCarthy, Thomas, "An Automatic Integrator for Ordinary Differential Equations for Illiac IV," (M.S.), Report No. 336, June 1, 1969.

(9) Rettig, J., "A Test Mode Approach to Fault Detection in Sequential Circuits," (M.S.), Report No. 326, May, 1969.

(10) Richardson, Beth, "Random Number Generation on the I.B.M. 360," (M.S.), Report No. 329, April, 1969.

(11) Vohra, Raj, "Study of Stability for Non-Linear Ordinary Differential Equations," (M.S.), Report No. 327, June, 1969.

(12) Wells, Richard, "The University of Illinois Attached Machine Operating System: Design Criteria and Program Logic," (M.S.), Report No. 327, June, 1969.

(13) Wilkins, S., "Representations of Process Parallelisms," (M.S.), Report No. 328, June, 1969.

11.3 Colloquia

"The Tricolor Cartograph and Other Hybrid Systems," by Professor W. J. Kubitz, University of Illinois, Department of Computer Science, April 7, 1969.

"A System for Interactive Computation," by Dr. T. S. Shao, Bell Telephone Laboratories, Murray Hill, New Jersey, April 14, 1969.

"Global Convergence of the QR Algorithm with Shifts of Origin and its Relationship with Rayleigh Quotient Inverst Iteration," by Dr. Jim Wilkinson, National Physical Laboratory, Teddington, England, April 21, 1969.

"Ideas for Nonarithmetic Computer Organization," by Dr. Allen C. Kay, Department of Computer Science, University of Utah, April 28, 1969.

"Numerical Mathematics--One Man's View," by Dr. Joe Traub, Association for Computing Machinery, Northern New Jersey Chapter, New Jersey, May 5, 1969.

"Language Design and Program Optimization," by Dr. Karl Balke, Computer Science Corporation, El Sigundo, California, May 19, 1969.

11.4 Drafting

During the second quarter, a total of 530 drawings were processed by both drafting sections:

	General	Pattern Recognition
Large Drawings	66	30
Medium Drawings	114	61
Small Drawings	19	151
Layouts	2	2
Report Drawings	31	0
Changes	41	0
Miscellaneous	7	6
TOTAL	280	250

(M. Goebel and J. Otten)

11.5 Shops' Production

Job orders processed and completed during the second quarter of 1969 are as follows:

	AEC 1018	AEC 1469	Other
Machine Shop	26	1	9
Electronics Shop	28	43	5
Chemical Shop	8	39	10
Layout Shop	9	34	1
TOTAL	71	117	25

Wiring of 403 printed circuit boards during this period accounted for 21,210 diodes, 3,517 transistors, and 460 integrated circuits. Repair and conversion of stock printed circuit boards amounted to 24 pieces.

(F. Serio)

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Physics

COO-1469-0148
COO-1018-1193

QUARTERLY TECHNICAL PROGRESS REPORT

July, August, September 1969

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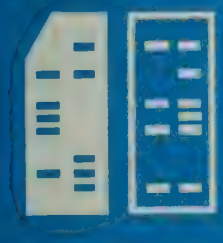

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN - URBANA, ILLINOIS

QUARTERLY TECHNICAL PROGRESS REPORT

July, August, September 1969

Department of Computer Science
University of Illinois at Champaign-Urbana
Urbana, Illinois 61801

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract N000 14-67-A-0305-0007, W. J. Poppelbaum, Principal Investigator)

Summary

During the summer, attention was focussed in two main areas: LASCOT and COLORMATRIX. M. N. Cooper has designed the deflection circuits for LASCOT. His report also discusses the detection and modulation schemes. S. Hadjistavros describes the methods he has developed for measuring and controlling the thermal properties of transistors, used to drive heat sensitive liquid crystals, in the COLORMATRIX project.

M. Faiman

1.1 LASCOT (Large Screen Color Television) Project No. 09

1.1.1 The Deflection System

The vibrating mirrors (galvanometers) have been ordered. The driving circuits for the mirrors (horizontal and vertical) have been designed and tested. The mirrors will be driven by a triangular waveform which is generated by the circuit shown in Figure 1. The input to this circuit is a square wave which turns on a current source and a current sink alternately, thus producing a triangular waveform across the capacitor C. The value given for the capacitor in Figure 1 is that used for the horizontal deflection mirror.

1.1.2 Detection System

The high voltage power supply for the photomultipliers has been designed and the components have been ordered. The photomultiplier tubes have been procured. The detection system is being assembled.

1.1.3 Modulation System

An electro-optic light modulator (EOLM) has been chosen. Three have been ordered from Crystalab Products, Inc., of type 3050. They have an electrical bandwidth of 0 - 100 MHz, a half wave retardation voltage of 450 volts and a capacitance of 25 pf.

The video driving amplifiers for the EOLMs have been designed but not yet tested.

M. N. Cooper

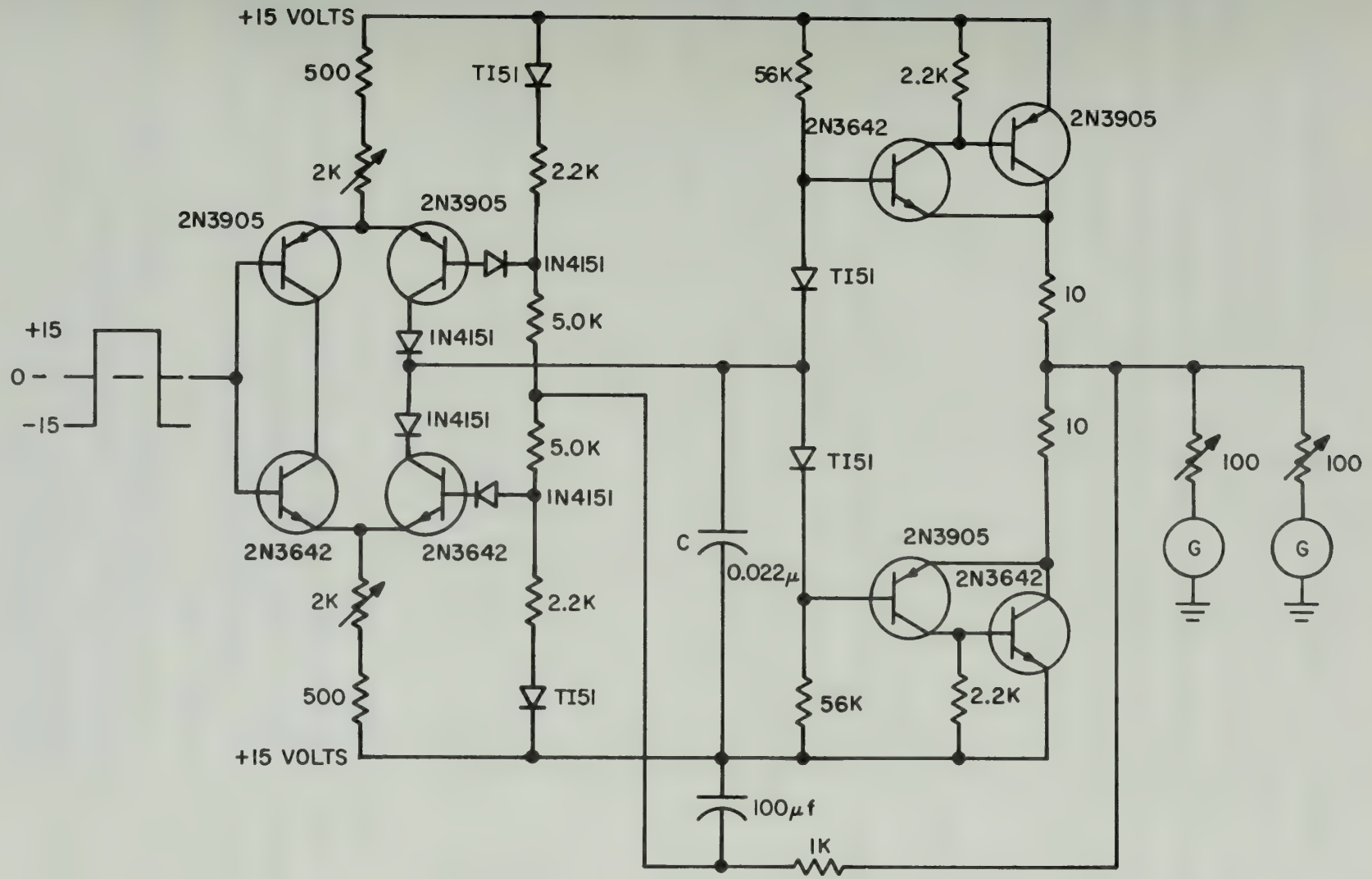


Figure 1. Triangular Waveform Generator.

1.2 COLORMATRIX (A liquid crystal colored Matrix Display) Project No. 27

Colormatrix is a display system using the thermal properties of "liquid crystals". For a feasibility model an array of transistors will be used, where the appropriate areas of controlled temperature on the display will be produced by the heat dissipated by their base-collector junctions. Preliminary devices were constructed in order to follow the changes of the temperature of the base-collector junction as well as of the case of the transistor.

1.2.1 Summary

The thermal signal picked-up from the case of a thermally tested transistor consists of two signals, A and B (Figure 1), ratio of amplitudes, A:B $\simeq$ 1:100. The separation of the two signals is accomplished by two operational amplifiers (Figure 3), one of which integrates the whole signal; the resulting B signal is then subtracted from the original thermal signal. The separated signal A is given at the output of a following sample-and-hold circuit (Figure 4).

Because of the presence of phase lag between the power pulse delivered to the transistor and the signal A, a correcting system is constructed to synchronize the sampling times for the signal A (Figure 5). Finally the appropriate amplifiers are interconnected in order to achieve for both A,B signals a level of 1 - 5 volts.

1.2.2 Thermal Signal

The signal produced by the introduction of power pulses in a medium power transistor (collector connected to case) is considered. For rectangular pulses, the two known cases for the B-C junction (thermal time constant τ_j) temperature are:

1. $t_1 \ll \tau_j$: only the average temperature of the junction changes because of the integration of the delivered power.

2. $t_1 \simeq \tau_j$: the change of junction temperature during every power pulse can be significant (Figure 1).

For the case of the transistor, the same behavior is valid, although with a bigger thermal time constant τ_c.

The changes of temperature during each power pulse can be distinct and observable if there is the appropriate time t_2 for the dissipation of the heat delivered by the power pulse P. In this case small changes of temperature according to the delivered power pulses are superimposed on the attained approximately constant average temperature. A phase lag exists between power pulse and thermal signal A. The quantities P, τ_c, t_1, t_2 are related in the above situation.

Two signals are of interest: (Figure 1)

Signal A: small changes of temperature following each power pulse.

Signal B: continuously increasing temperature toward the value corresponding to the final average temperature.

As a thermal transducer a diode of small τ_c ($\frac{dV_j}{dT} = -2mV/^{\circ}C$) is used. The values of the above thermal signals are:

A: of the order 0.1 - 0.5°C, so $\simeq$ 0.2 - 1 mV

B: of the order 20°C, so $\simeq$ 80 mV

Ratio of amplitudes A:B $\simeq$ 100.

Because it is important for the display to be outside of the region of changes of the ambient temperature, a value of operation above $\simeq$ 40°C is to be selected. Therefore in order to avoid having to spend during every cycle the long time required to drive the case of the transistor from T_1 to T_2, the reasonable solution is to keep the case of the transistor in the region of T_2 by means of a constant thermal bias and give another superimposed power pulse to produce the small temperature changes corresponding to signal A, which are required for the operation of the display.

1.2.3 Power Pulse Systems

For a medium power transistor T_1, the circuit of Figure 2 was selected. Although very simple, it is satisfactorily reliable and stable. The power required for the average temperature is introduced by V_1, R_1,

V_{CC} (= signal B) -- thermal bias of the transistor -- and the power required for the signal A is introduced by V, R_2, T_2, V_{CC}. In the present case power pulses of approximately 600mW are necessary for a 0.2°C temperature change.

1.2.4 Circuit for Separation of Signals A and B

The signals A and B must be measured separately. For this goal the circuit of Figure 3 is used. The signal (= junction voltage of the diode D) is led to operational amplifiers OP1, OP2. The second amplifier integrates the signal, transforming it approximately to the form of the signal B. This signal, inverted, is fed back to the input of OP1, and so is subtracted from the original signal. Therefore, at the output of OP 1, one obtains the signal A and at the output of OP2, the signal B.

The biasing system of R_1, R_2, R_3, R_4 of the diode D is to keep $V_D \simeq 0$ at room temperature in order to eliminate useless background voltage. The system works satisfactorily if OP1, OP2 have very small DC offsets and good thermal stability. For the operational amplifier FSL-6 used, the DC offset was about 0.1 mV. Capacitors and precise resistors of small temperature coefficient are used. C_1, C_2 are simply compensating capacitors.

1.2.5 Sample and Hold Circuit

The measurement of signal B introduces no problems. The small amplitude of signal A as well as the instability ($\pm 10^{-4}$v) of the diode D bias and the DC offset voltages of the amplifiers were the main reasons for no accurate measurement of signal A on the scope directly.

A measuring system consisting of a simple PEAU-SAMPLER and HOLD circuit is not a practical solution. The solution followed is the use of two sample-hold operational amplifiers for uniform hold times and the subtraction of the resulting amplitudes of signals in a following operational amplifier (Figure 4).

The aperture time is selected by R_1, C_1 and R_3, C_2; values of 10 - 50 msecs. For the present work, t = 1.5 - 2 secs. The memory of the system can be improved by selection of low leakage current capacitors of values as big as possible, limited by the required aperture times. In the

present circuit the aperature time ≃ 50msecs; the output voltage of the hold circuit decreases by a rate ≃ 10mV/sec which is considered as satisfactory (final level of signals A,B ≃ 1 - 5 volts).

1.2.6 Phase Lag and Drivers

Because of the phase lag of the signal A relative to the power pulse, a system of two monostable and one bistable multivibrators is constructed to produce the required compensation for synchronizing switches S_1 and S_2 (Figure 5). The signal is then fed to two drivers (one monostable and one inverter) which drive the switches S_1, S_2 (fast read relays).

The switches S_3, S_4 alternately connect the amplified A,B signals to a digital voltmeter for equal time intervals. The drivers S_3, S_4 are derived from another signal produced independently by an astable multivibrator (T ≅ 1.5 - 2 secs for easy observation). The digital voltmeter gives the changing values of signals A,B during the time intervals of measurements. The whole system is completed by the addition of a few amplifiers interconnected in order to achieve for both A,B signals a level of 1 - 5 volts.

S. Hadjistavros

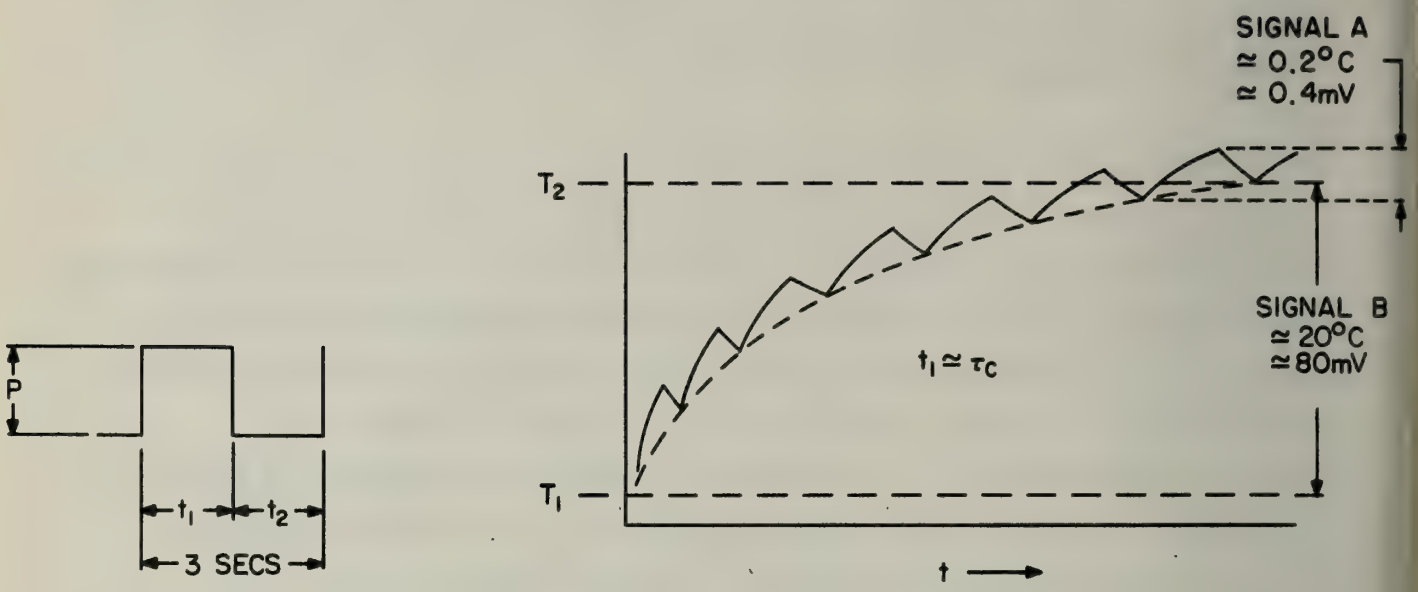


Figure 1. Power Pulse and Thermal Signals.

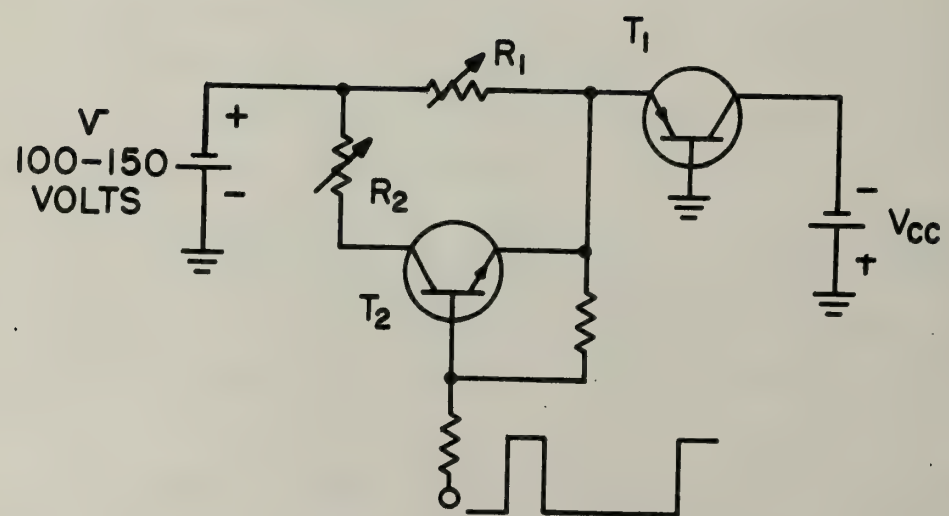


Figure 2. Power Pulse Circuit.

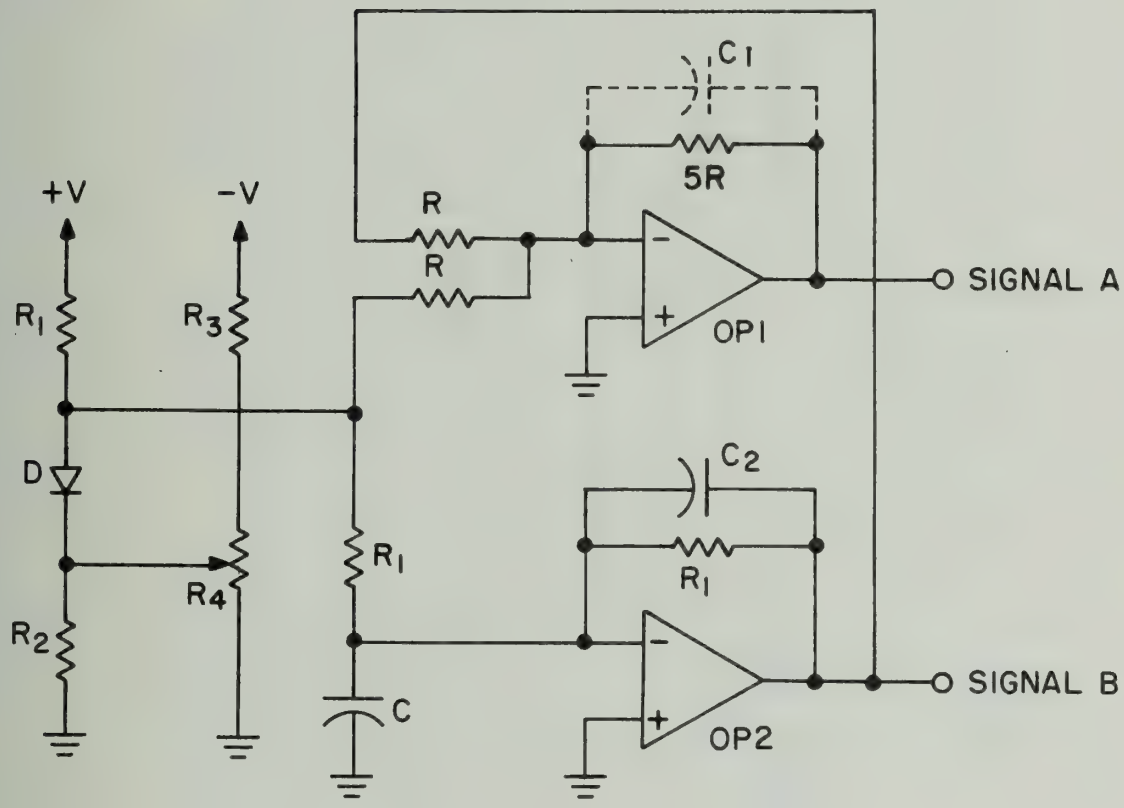


Figure 3. Circuit for Separating Signals A and B.

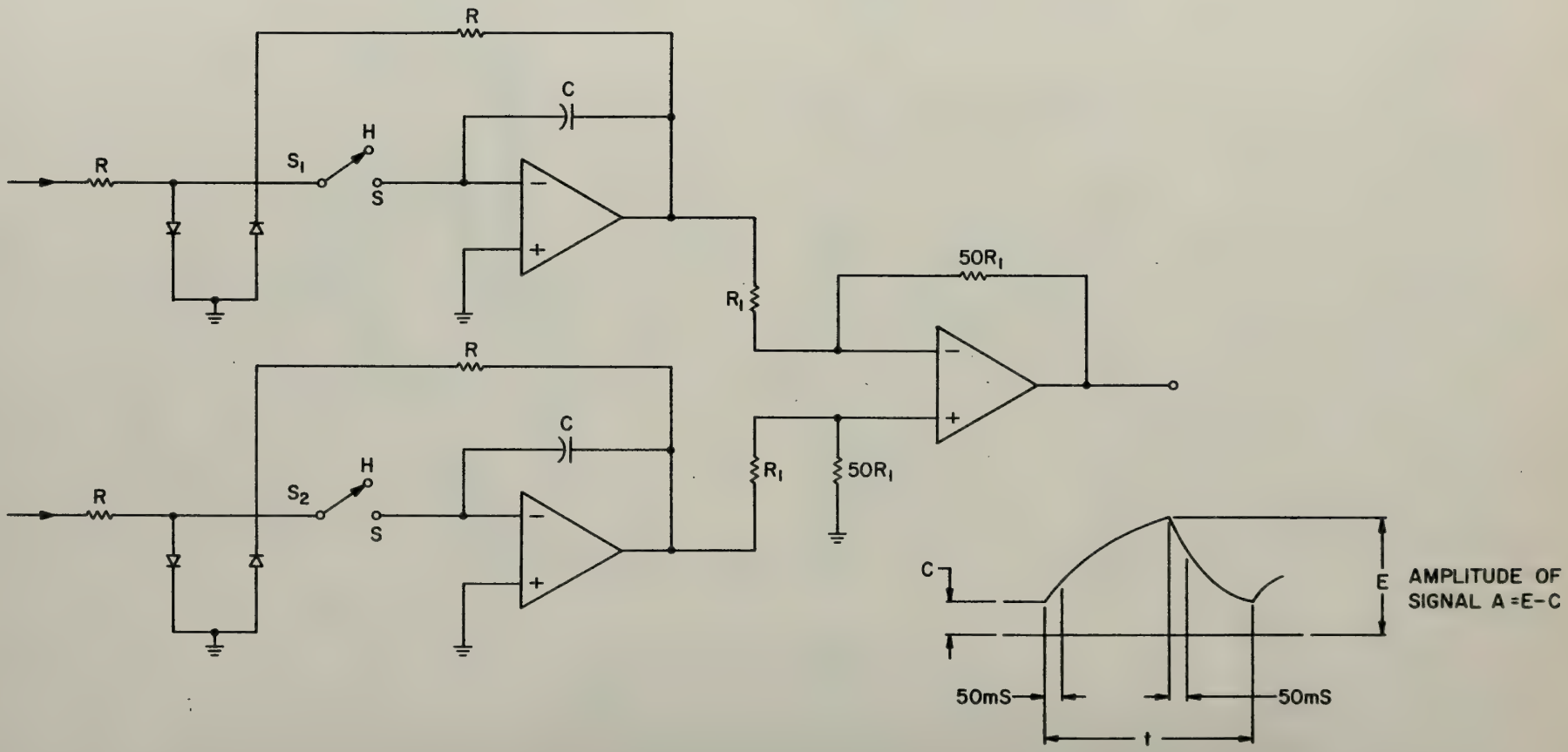


Figure 4. Sample and Hold Circuit.

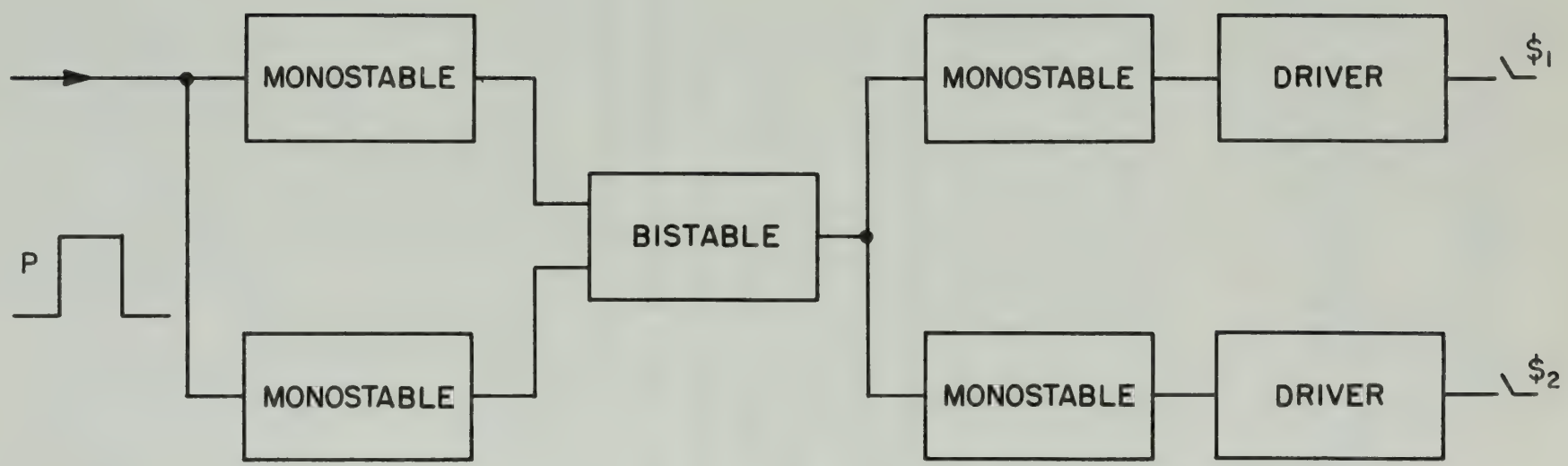


Figure 5. Phase Lag and Drivers.

2. HARDWARE SYSTEMS RESEARCH

(Supported in part by the Atomic Energy Commission under Contract US AEC AT(11-1) 1469, W. J. Poppelbaum, Principal Investigator.)

Summary

Doug Sand describes circuit changes to the erase gun assembly of OLFT, designed to ensure more reliable and uniform operation. Further modifications to ORBIT to allow more realistic representation of horizontal lines have been made by Pete Oberbeck. He and Ed Carr are also working on a scheme for properly synchronizing the receiver. Larry Wallman reports on a design change in the conducting stripes which go on BLAST's lenticular screen, and describes the video chopper and mixer to be used in the system. The TRANSFORMATRIX report is in three parts: Orin Marvel discusses a method of equalizing the response of a group of photodetectors, describes the function of one of the 32 stochastic processors, and also the generation of low frequency clocks from a master. The method of coefficient storage and D/A conversion is described by Larry Ryan; while Yiu Wo discusses circuitry for driving the display. For the STEREOMATRIX project there are reports by Chuck Pirnat, Dick Cheng, Shiv Verma and Steve Whiteside, dealing with the observer's position detector, processor coefficient generator and display cursor, matrix transformer, and the final display.

M. Faiman

2.1 OLFT (On-Line Fourier Transform System) Project No. 12

2.1.1 General Progress

A series of experiments determined that the erase gun circuits required more stability and better regulation for consistent operation. Accordingly, the erase gun power supplies and pulse circuits were completely redesigned, as discussed in section 2.1.2.

Two minor equipment failures caused considerable delay, so that the planned resolution and crystal tests were postponed. First, the write-gun cathode potential power supply (20 kV) lost regulation when a multiplier resistor opened, for no apparent reason. This resistor - a 10 MΩ, 1% precision resistor - required a special order for replacement. Second, the laser power output dropped to 25mW, and its dc current supply regulation failed. The low power output was caused primarily by dirty resonator mirrors. The current supply failure was more difficult to determine: after about 10 minutes of operation a control transistor (2N1665) would develop a large leakage current (initially about 1μA, rising to about 0.5mA), saturating the series regulator tube. Since this transistor is located near the regulator tube (which dissipates 50W) it is probably that the large leakage current was caused by junction overheating. Whatever the cause, a substitute transistor (2N2905A) has performed quite well over 20 hours of operation.

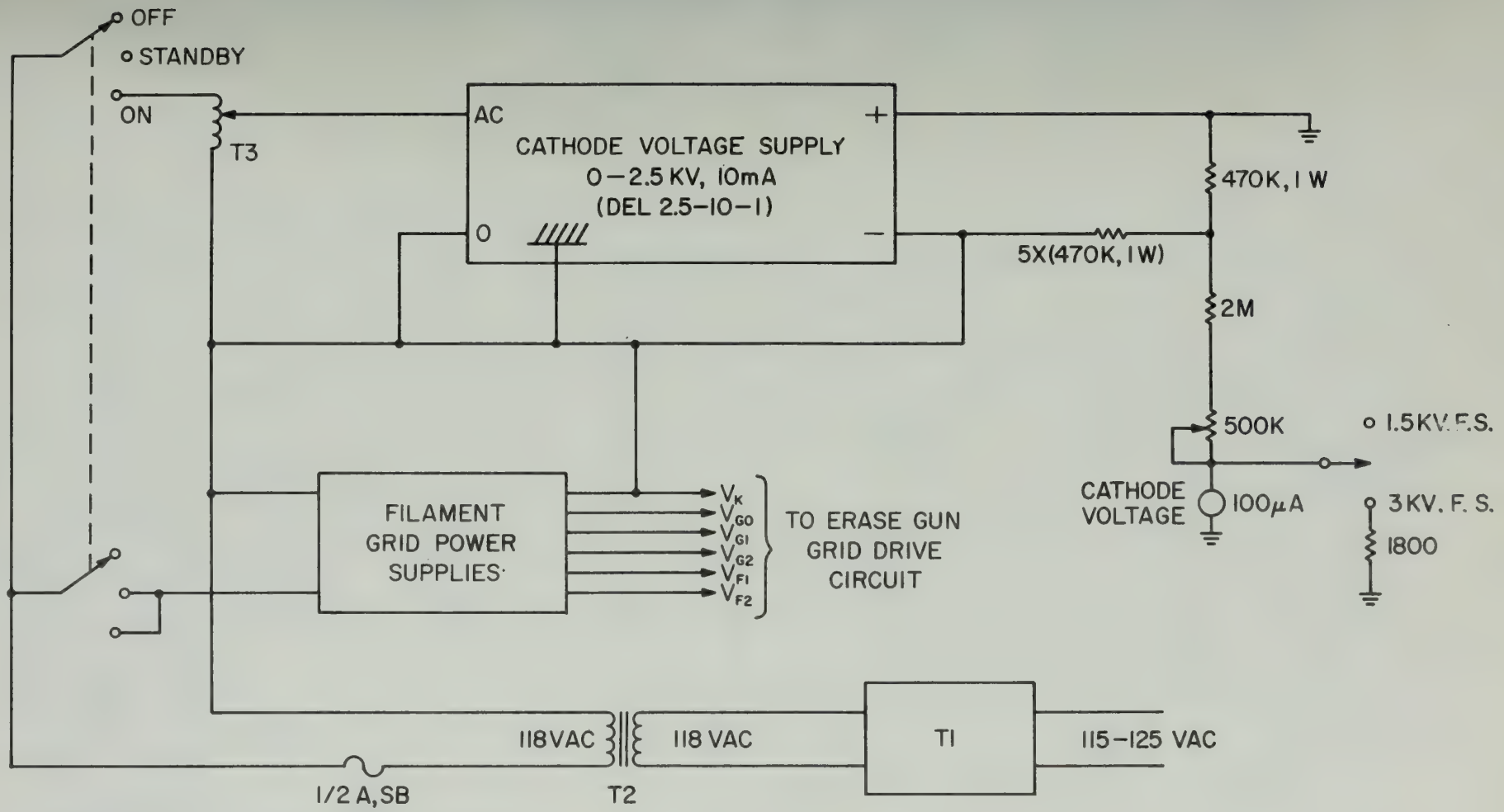
A method has been found to properly synchronize the Alphechon subsystem and the Cohu vidicon camera to a standard live video signal. The video and deflection circuits for each subsystem require four synchronized drive signals (sync, blanking, horizontal and vertical drive) which are usually generated by a master sync circuit, requiring special circuits for locking to a master video signal. However, a Cohu circuit card called a "drive pulse generator" can extract the four drive signals directly from the composite sync contained in the video signal. This circuit card replaces the master sync board and external circuitry. The drive pulse generator as received required some modification to operate properly (an input coupling capacitor and a cable termination were added), and now operates reasonably well. Unfortunately, the circuit is unduly susceptible to noise pulses, so additional modifications will be necessary.

Finally, attempts continue to find a more reliable, less expensive crystal configuration. For example, our crystal supplier will attempt to repolish a crystal which has been "etched" during operation - repolishing may result in a considerable saving in crystal costs. The investigation of Curie - temperature operation has shown promise, and the proposed system modifications will be discussed in detail in the next quarterly report.

2.1.2 Erase Gun Modifications

Operational circuits for the erase gun power supplies and grid driver were described in the preceding quarterly report. Unfortunately, subsequent experience has shown that these circuits are inadequate. Several difficulties were encountered, and successive revisions have led to a complete redesign of all circuits.

First, the cathode potential circuit - a multi-position switch, resistor chain, and simple unregulated voltage supply - lacked sufficient resolution to establish a proper low-voltage erase bias. Much better resolution (about 0.5%) and far better thermal stability were obtained by controlling the cathode potential with an autotransformer at the voltage-supply input, as shown in Figure 1. It was necessary to float the auto-transformer at cathode potential since line voltage was required for the filament and grid supplies. It was found that the in-house line voltage varied from 115 to 125 Vac during the day, so a constant voltage transformer and a cathode potential meter were included to stabilize operational conditions. Obviously, it was no longer possible to obtain the appropriate grid-voltages from simple taps in the resistor chain, so that two grid voltage supplies were designed to float at cathode potential, as shown in Figure 2. These new grid supplies eliminated another problem: in the previous circuit the grid voltages during turn-on increased in proportion to the cathode potential; thus, even though the grid pulse circuit was turned off, the improper grid voltages allowed erase current during turn-on, forcing the target to fall to cathode potential rather than to stabilize at the second-crossover potential (relative to cathode potential). The new grid-voltage supply keeps the erase gun cutoff during turn-on, so that stable erase-bias operation at the second cross-over potential can be reliably obtained without difficulty.

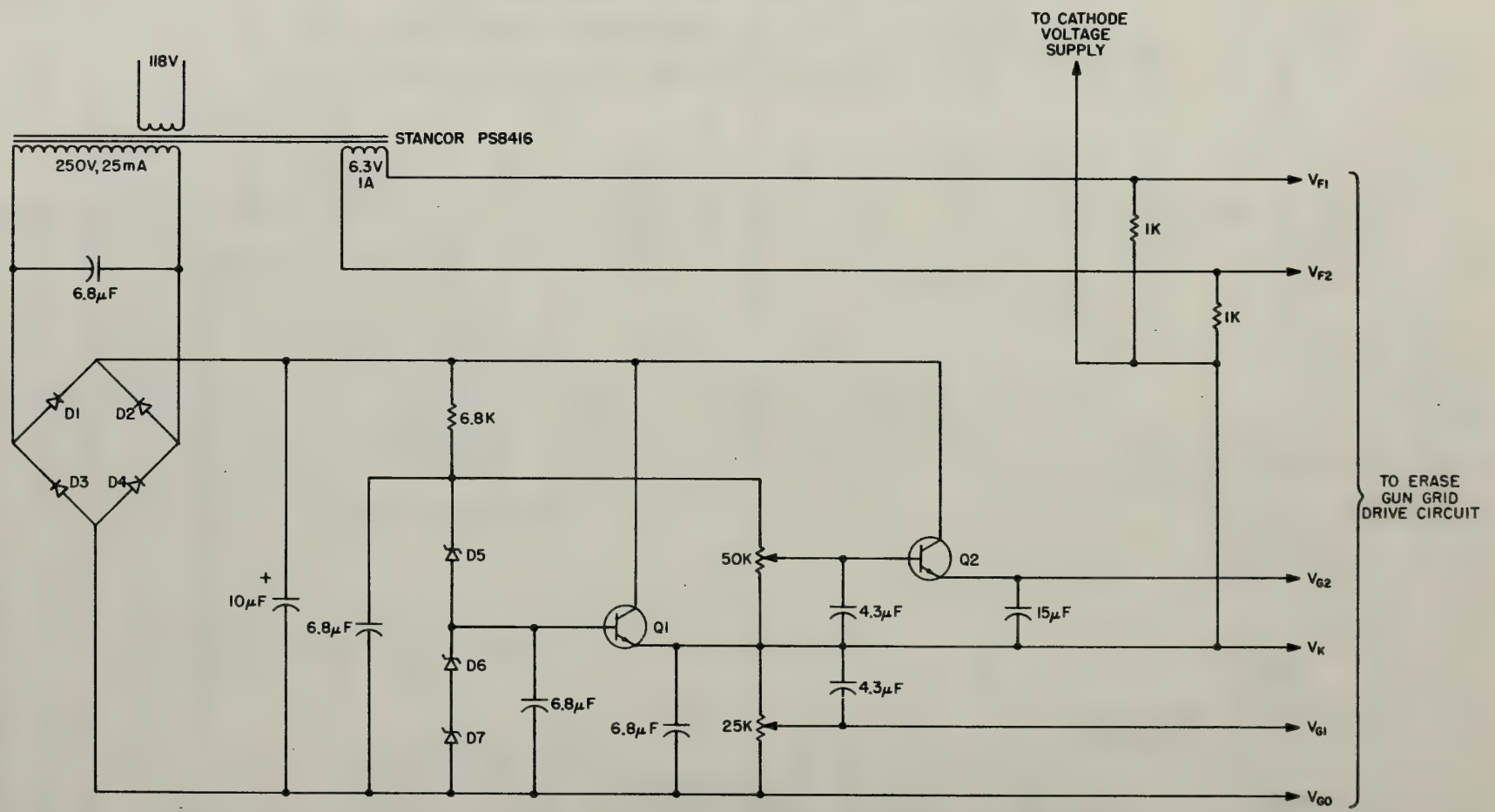


T1: CONSTANT VOLTAGE TRANSFORMER (SOLA TYPE CVS, 60VA)

T2: ISOLATION TRANSFORMER (DEL AD–1640, 10KV)

T3: AUTOTRANSFORMER (STACO TYPE 175–BU)

Figure 1. Erase Gun Power Supply.



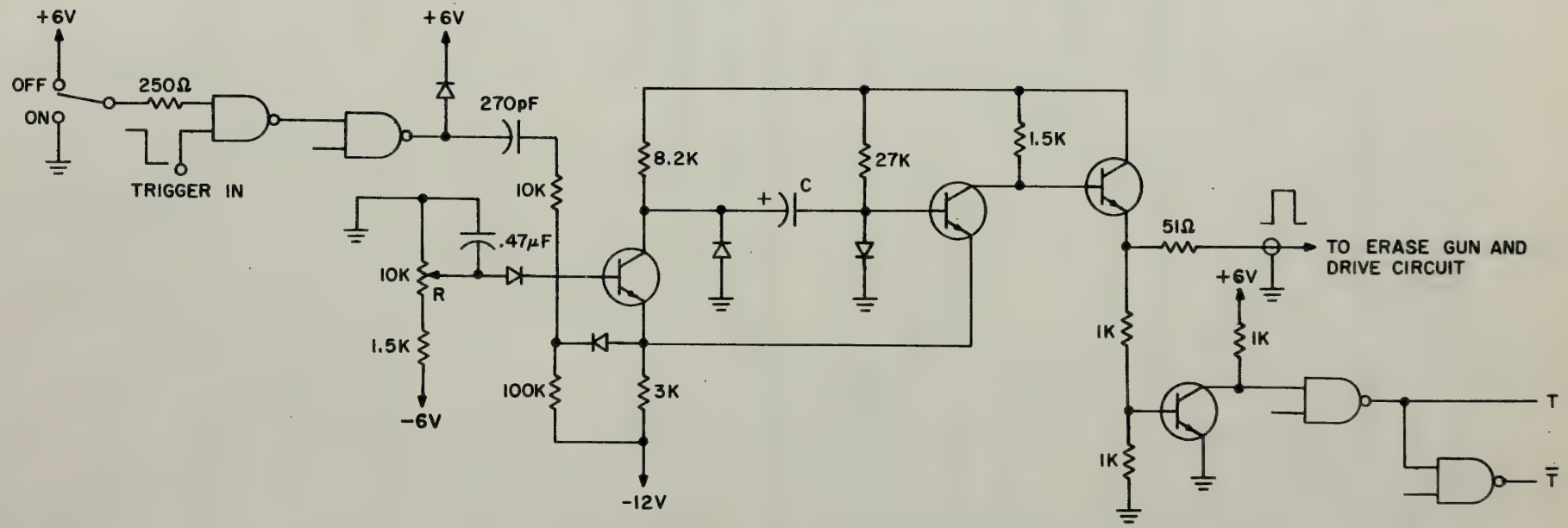
D1,2,3,4 = IN4004
D5,6,7 = IN4764A (V_Z = 100, 1W)
Q1,2 = 40327
$V_K - V_{G0}$ = 200V

Figure 2. Erase Gun Filament and Grid Voltage Circuit.

Finally, because of power supply changes and other considerations, the grid drive circuits were completely changed. First, the grid driver (floating at cathode potential) was moved from the power-supply box (where it was subject to excessive ambient temperature) to a location close to the erase gun; in addition to a better thermal environment, this eliminates the capacitance associated with the twenty feet of coaxial cable connecting the erase gun and the old drive circuit. Second, in the old circuit the pulse was generated by a one-shot floating at cathode potential, triggered through a pulse transformer, with pulse duration controlled by a floating potentiometer. This proved inconvenient in the old and new configurations, so that the pulse duration is now controlled by a low-level one-shot, as shown in Figure 3. The new grid drive circuit, shown in Figure 4, also contains a one-shot, which is triggered on and off through the pulse transformer. The use of a one-shot driving the grid is a safety feature, since in case of a low-level failure or a noise-pulse trigger, the maximum erase pulse is about 2.5ms, reducing the possibility of target damage due to excessive erase current.

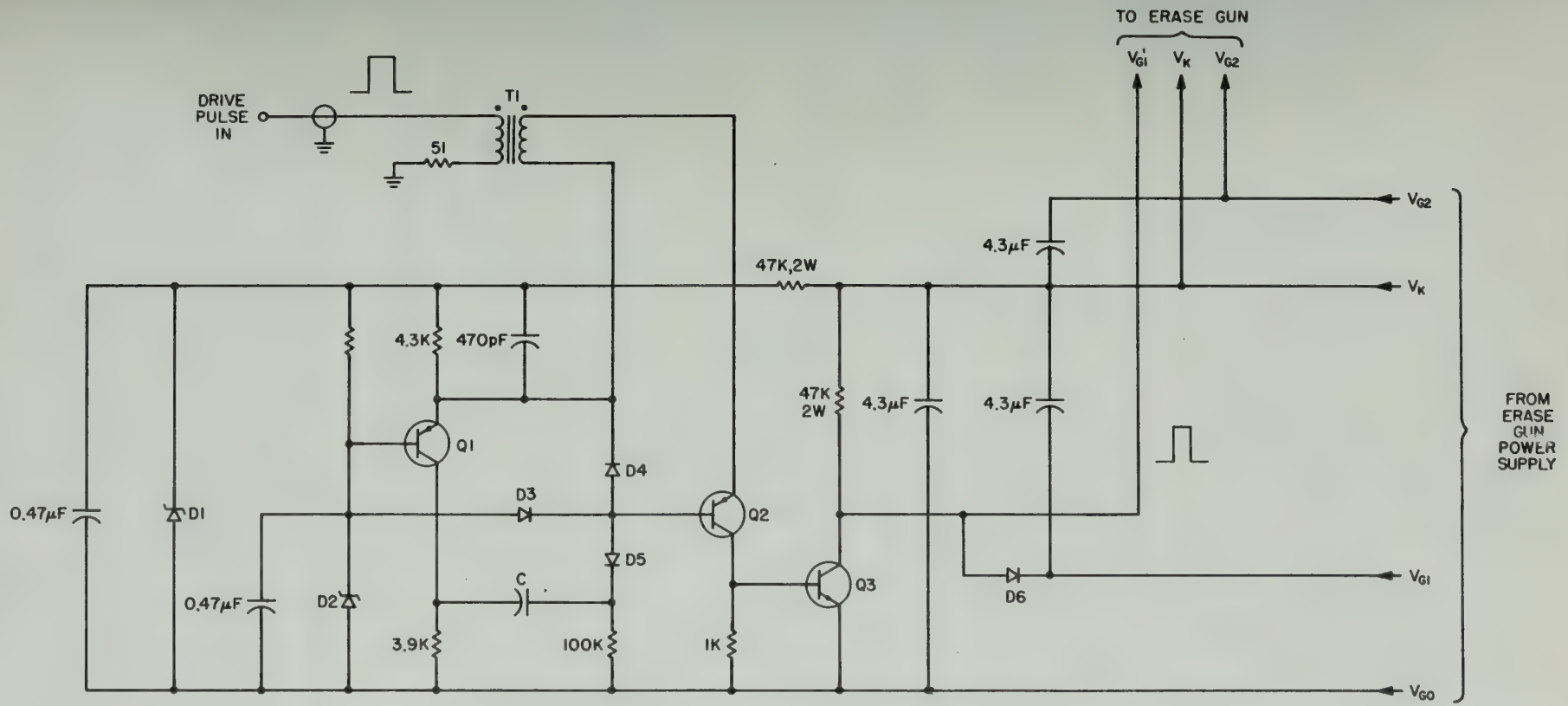
The new erase gun circuits have worked quite well. Since these new circuits have been operating, only a single uncoated crystal has been tested, so that a general description of erase characteristics will be deferred until more extensive experience has been obtained with other crystals.

Doug Sand



C=0.15μF FOR 2.5mS MAX. PULSE DURATION
R SETS DURATION, 50μS TO 2.5mS
ALL DIODES IN4151
ALL TRANSISTORS 2N3642
ALL NAND-GATES ARE 1/4 - SN7400N

Figure 3. Erase Gun Drive Pulse Generator.



D1 = IN960A (10V)
D2 = IN752A (5.6V)
D3,4 = IN4151
D5 = IN995
D6 = IN4004
Q1,2 = 2N3905
Q3 = 40327
T1 = 1/2" TORROID (FERRITE, 5μS PULSE), 1:1, 10 TURNS #28 NYCLAD, 3KV ISOLATION

$V_K - V_{GO} = 200V$

Figure 4. Erase Gun Grid Drive Circuit.

2.2 ORBIT Project No. 15

2.2.1 The Horizontal Line Problem

Although a solution to the horizontal line problem has been found, the solution is not quite adequate. The circuitry involved has to make a decision whether a signal corresponds to a point on a line. This is done by measuring the time duration of this signal. If its duration is greater than some predetermined time (typically 200ns) then it is considered a line; if less than, it is a point. Points displayed on the receiver are typically of 50ns duration. This means that there is a jump of 150ns from a point to a line and no values in between. This causes an undesirable broadening of the lines as they curve from vertical to horizontal. For this reason the scheme has been discontinued. The latest scheme is to only transmit points, and lines as a series of points. This limits the length of any horizontal line to a series of thirty-two points. A limitation that will only be noticeable for perfectly straight horizontal lines. In spite of this shortcoming, it is felt that this is a better solution than the scheme which fattens the lines.

2.2.2 Receiver Synchronization

At present the receiver is synchronized to the transmitter through a separate sync cable. The original plan was to incorporate synchronization through the low bandwidth channel. This problem is presently being worked on. It essentially consists of making use of the horizontal and vertical retrace time to send synchronization information. The following information must be transmitted: horizontal sync, vertical sync, and odd or even frame information.

The last and final problem is that of the synchronization of the 9.45 MHz clock in the receiver to the one in the transmitter. This problem is being solved by Ed Carr at the present. When these last few things have been finished, documentation of the system will begin.

Peter Oberbeck

2.3 TRICOLOR CARTOGRAPH Improvements Project No. 16

A television camera for outline input is being ordered. The shades of gray problem was looked into. The problem is that the disk may not be appropriate for reading and writing analog signals. Preliminary experiments seem to suggest that it is possible. Finally, thought has been devoted to the solid horizontal line problem. Theoretically, use of a rapidly responding rectifier stage followed by a low pass stage should give us the desired result. Development is underway.

Don Hanson

2.4 BLAST Project No. 19

2.4.1 Special CRT

The special cathode ray tube required for the BLAST system has been ordered from ElectroVision Industries, Inc., El Segundo, California. The conducting stripes on the lenticular screen inside the CRT have been changed from aluminum stripes deposited on top of the phosphor to NESA transparent type conducting stripes laid down underneath the phosphor. The purpose of these conducting stripes is to provide a means of obtaining a signal to use in stabilizing the scanning pattern underneath the cylindrical lenses of the lenticular screen.

2.4.2 Video Chopper and Mixer

The video chopper and mixer have been designed and constructed. The design is shown in Figure 1, Video Chopper. The 5.04 MHz astable multivibrator is also shown in Figure 1. The chopper signal from the astable is used to switch a constant current between a pair of combined differential amplifiers. The signal from the differential amplifiers is buffered and amplified by a common base amplifier. An emitter follower is used to drive the 75 ohm coaxial line to the monitor. Work is continuing on improving this design.

Larry Wallman

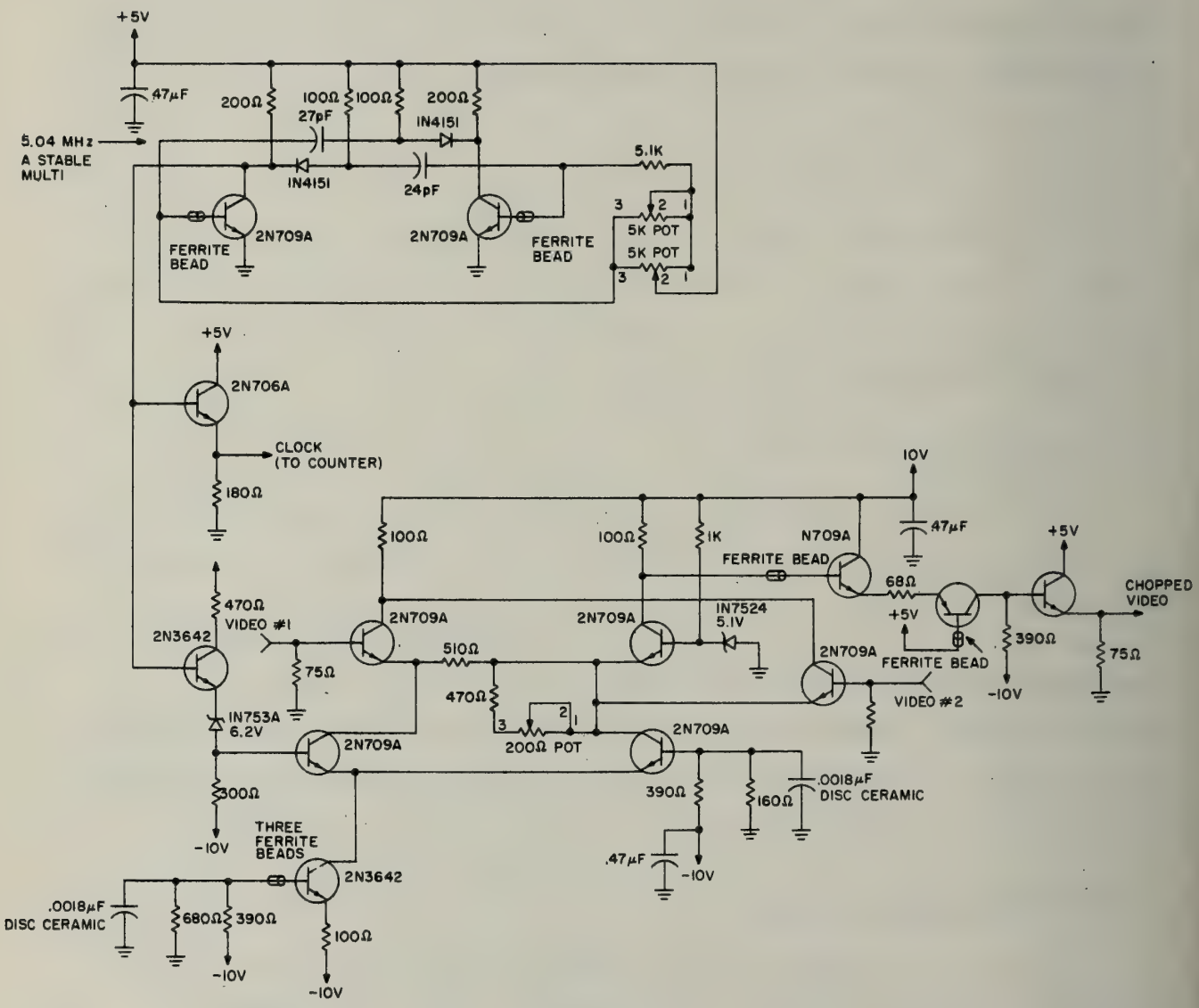


Figure 1. Video Chopper.

2.5 TRANSFORMATRIX Project No. 17

2.5.1 "Model T"

The "Model T" system built to demonstrate the high speed stochastic multiplication needed for the TRANSFORMATRIX system has been completed. Any further information on this system can be found in the Department of Computer Science Report 394, August 1969.

2.5.2 Input Processor

The 32 printed circuit cards of the Input Processor section are being built and tested. Figure 1 shows one of 32 processor circuits which compensate for the photoconductors and provide low impedance drive to the stochastic processor stage.

The transfer function of the photoconductor is given by

$$R = R_0(I)^{-.84}$$

where R is the resistance in ohms, R_0 is the resistance at one foot candle which may vary $\pm$ 33%, and I is the intensity in foot candles. With the photoconductor as the input resistor and a trimpot R_F as the feedback resistor of the operational amplifier - Figure 1 -, the output voltage of the op amp is

$$V_{INT} = \frac{R_F}{R_0} V_S(I)^{.84}$$

Thus with V_S a standardized voltage, the variation in R_0 can be cancelled by adjusting R_F to make all photo processors have the same transfer function.

2.5.3 Stochastic Processor

Figure 2 shows one of 32 processor circuits which connect the V_{INT}s to Synchronous Random Pulse Sequence (SRPS) signals, convert the $V_{CONSTANT}$s to (SRPS) signals, multiply the two independent (SRPS) signals,

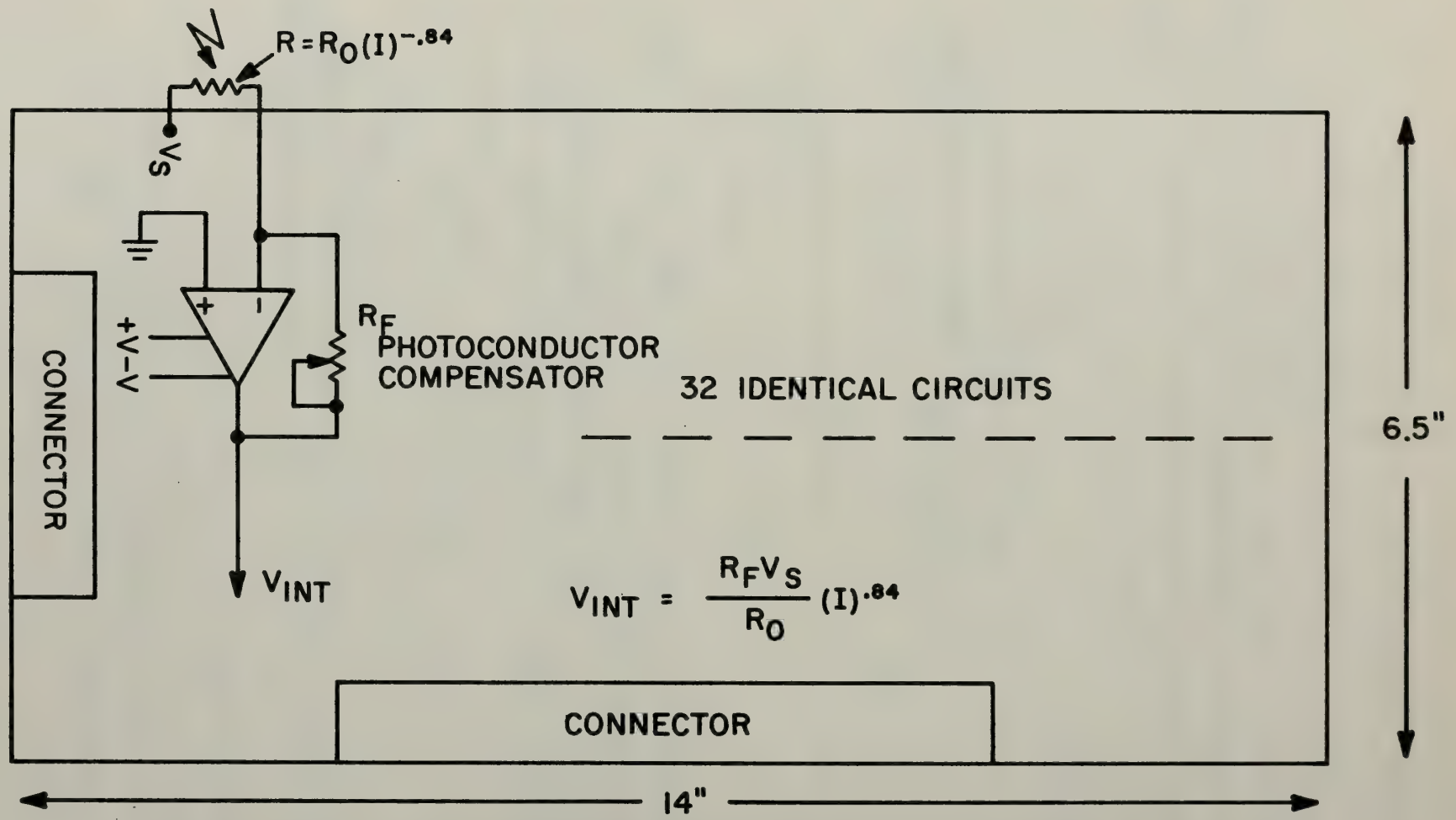


Figure 1. Input Processor Section.

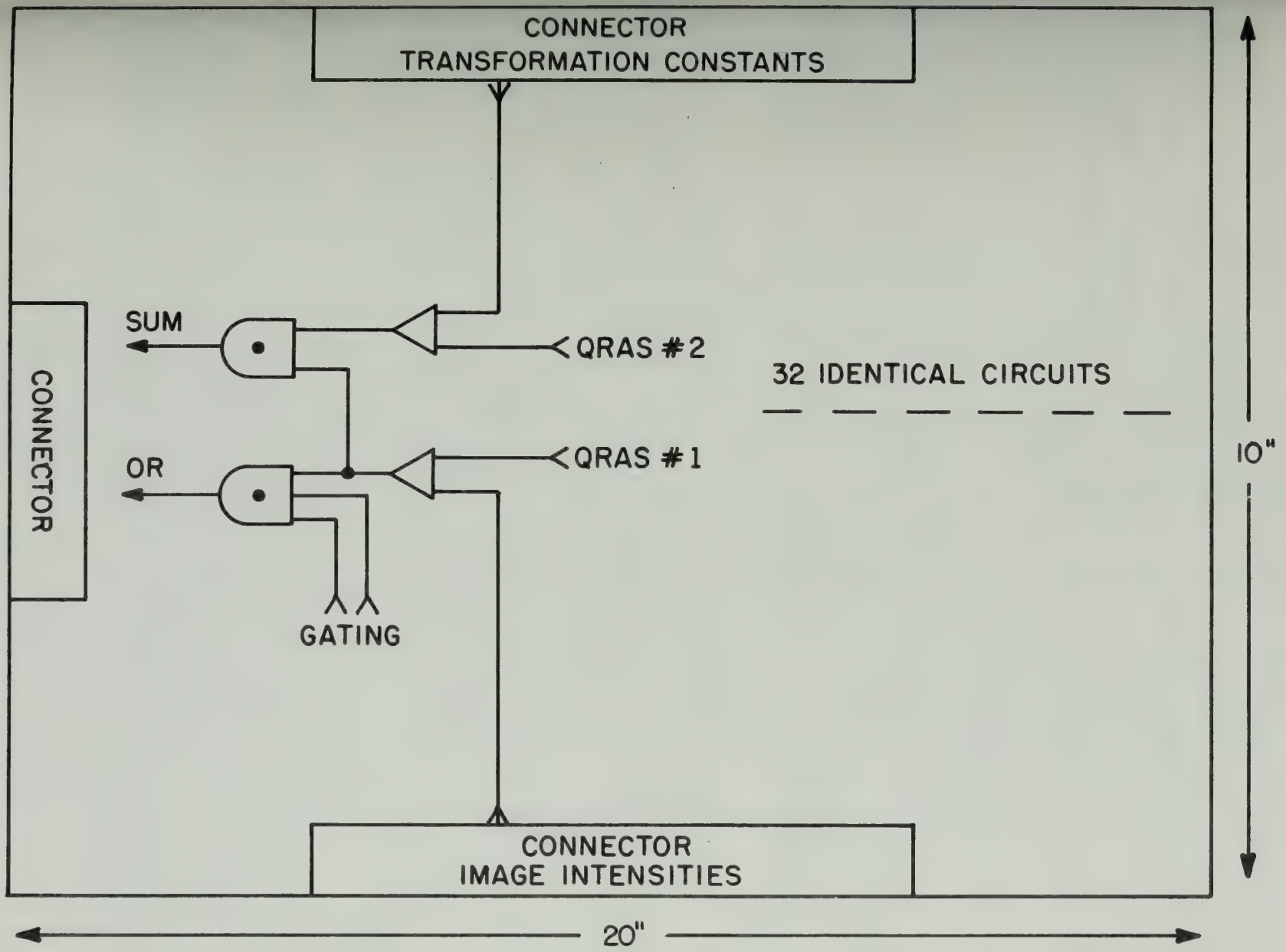


Figure 2. Stochastic Processor Section.

and multiplex the (SRPS) signals representing V_{INT}s. The (SRPS) signals are produced by comparing the V_{INT}s and $V_{CONSTANT}$s against Quantized Random Analog Signals (QRAS) with a 710 voltage comparator which produces a logical one whenever the input voltages are greater than the QRAS voltage. The stochastic multiplication of the two SRPS signals is accomplished by an "AND" gate. An "AND" gate is also used to multiplex the components of the input picture when gated by the M and N gating signals.

2.5.4 Clock Generation

Figure 3 shows a circuit which starts with a 9.984 MHz master clock and produces a 30.72 KHz clock of about 500ns pulse width. Using this method all available I.C. gates were used; but with the usual method these would be spares and two more packages would be required. Two variations of this method are possible depending on whether $\overline{\text{master clock}}$ is available or not.

When $\overline{\text{master clock}}$ is available, one coincidence circuit is wired for the binary count of N = (master clock frequency)/(required gating signal frequency) - N can only be an integer -- while the other coincidence circuit sets the period of the output pulse. Figure 4 shows a counter which produces a clock 1/5 the frequency of the master clock and whose pulse width is one master clock period wide. The counter counts master clock pulses until the NAND gate reaches coincidence, resetting the control flipflop, which resets the counter. The next falling edge of $\overline{\text{master clock}}$ then sets the control flipflop, and the counter reset is lifted. Thus the next clock pulse starts another counter cycle.

When $\overline{\text{master clock}}$ is not available, one coincidence circuit is wired for the binary count of p = (N-1) and the other set for the required output pulse width. The only difference between Figure 5 and Figure 4 - both producing the same gating signal - is that in Figure 5 the first clock pulse, after the control flipflop has been reset, sets the control flipflop while not affecting the counter. Thus the second master clock pulse restarts the counter cycle.

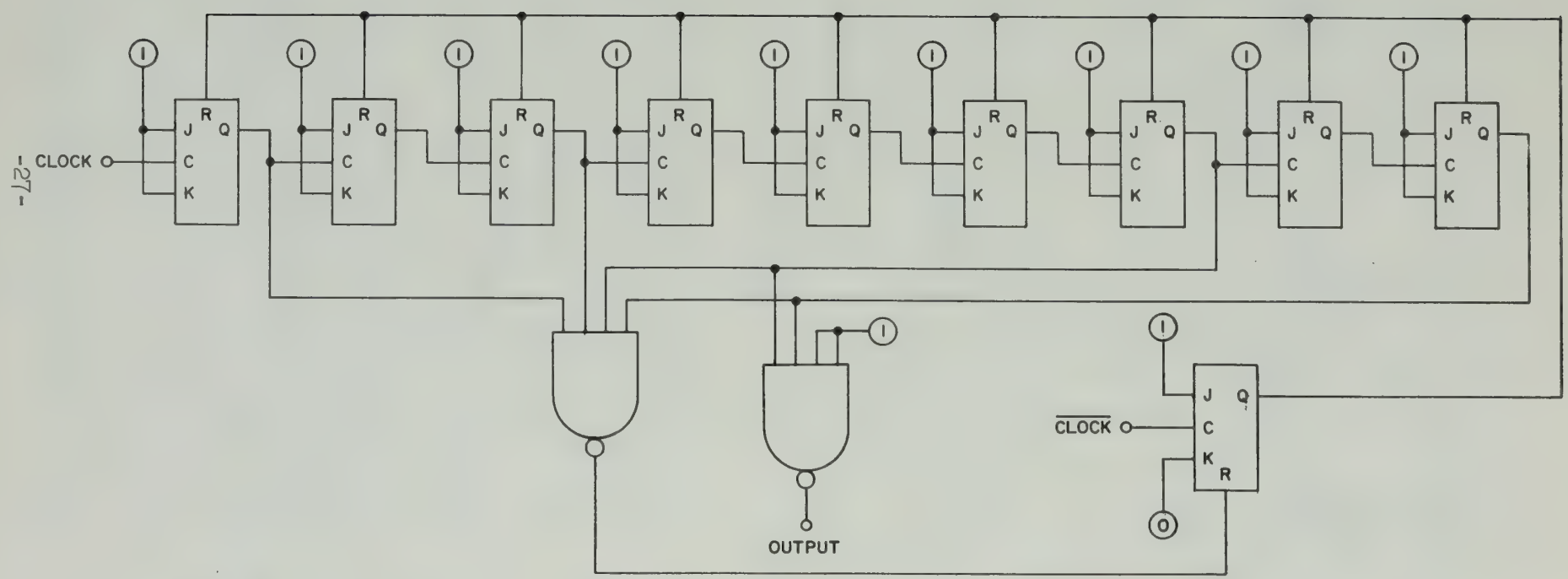


Figure 3. 30.72 kHz Clock of 500ns Pulse Width
Produced from a 9.984 MHz Clock.

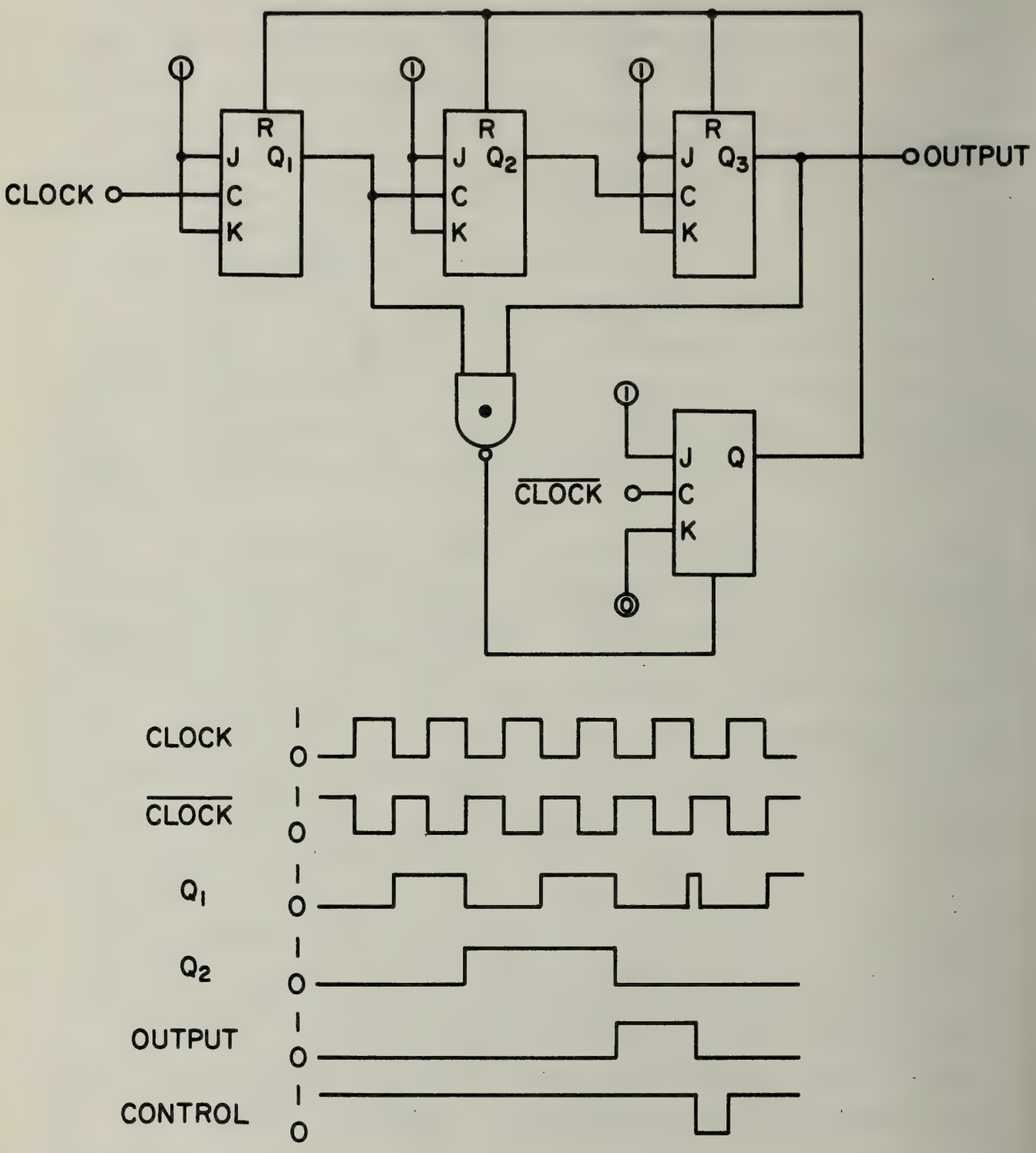


Figure 4. Clock and $\overline{\text{Clock}}$ Available.

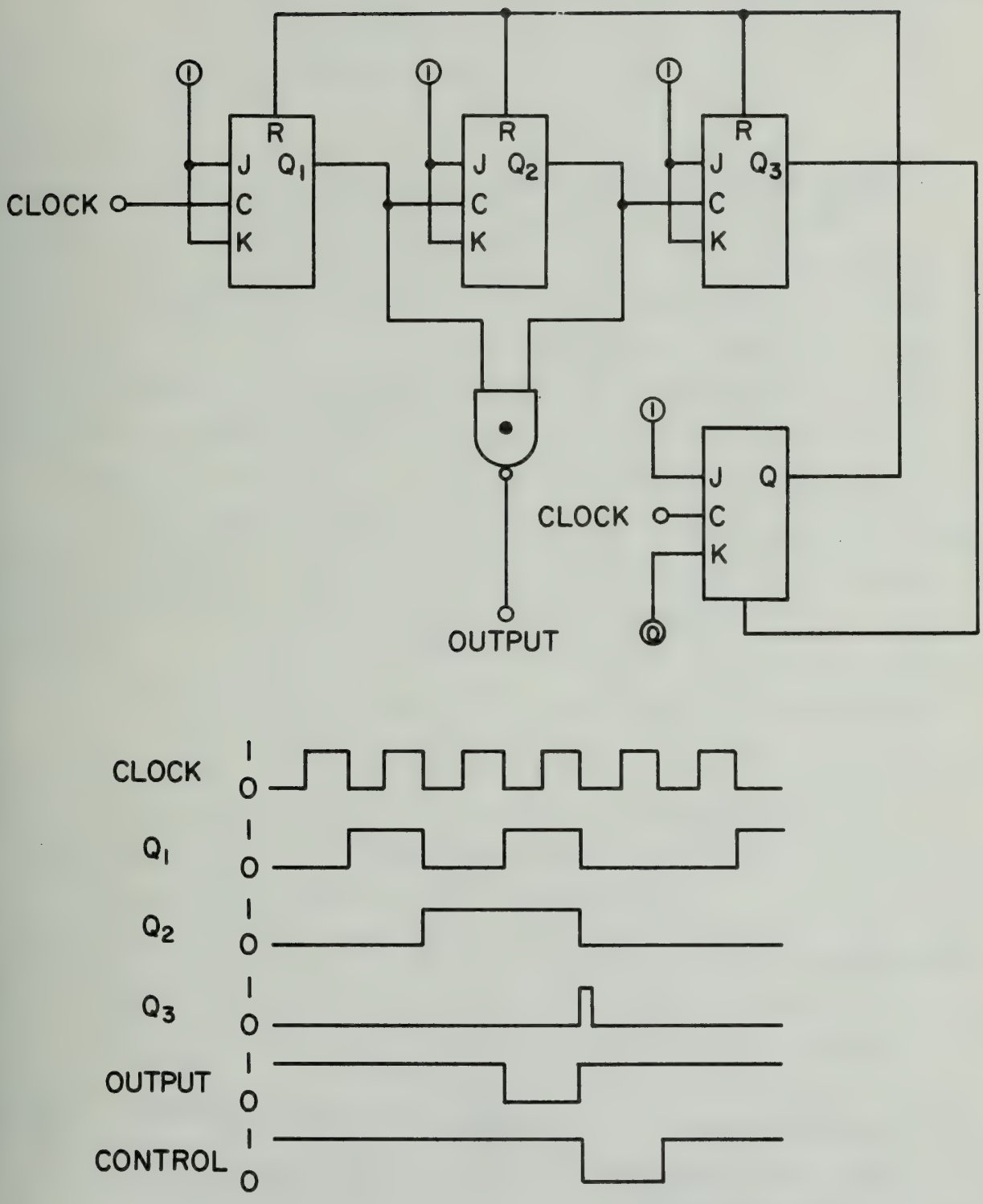


Figure 5. Only Clock is Available.

The above method has been used with ripple counters, but can also be used with synchronous counters.

Orin E. Marvel

2.5.5 Digital Storage of Coefficients and D/A Conversion

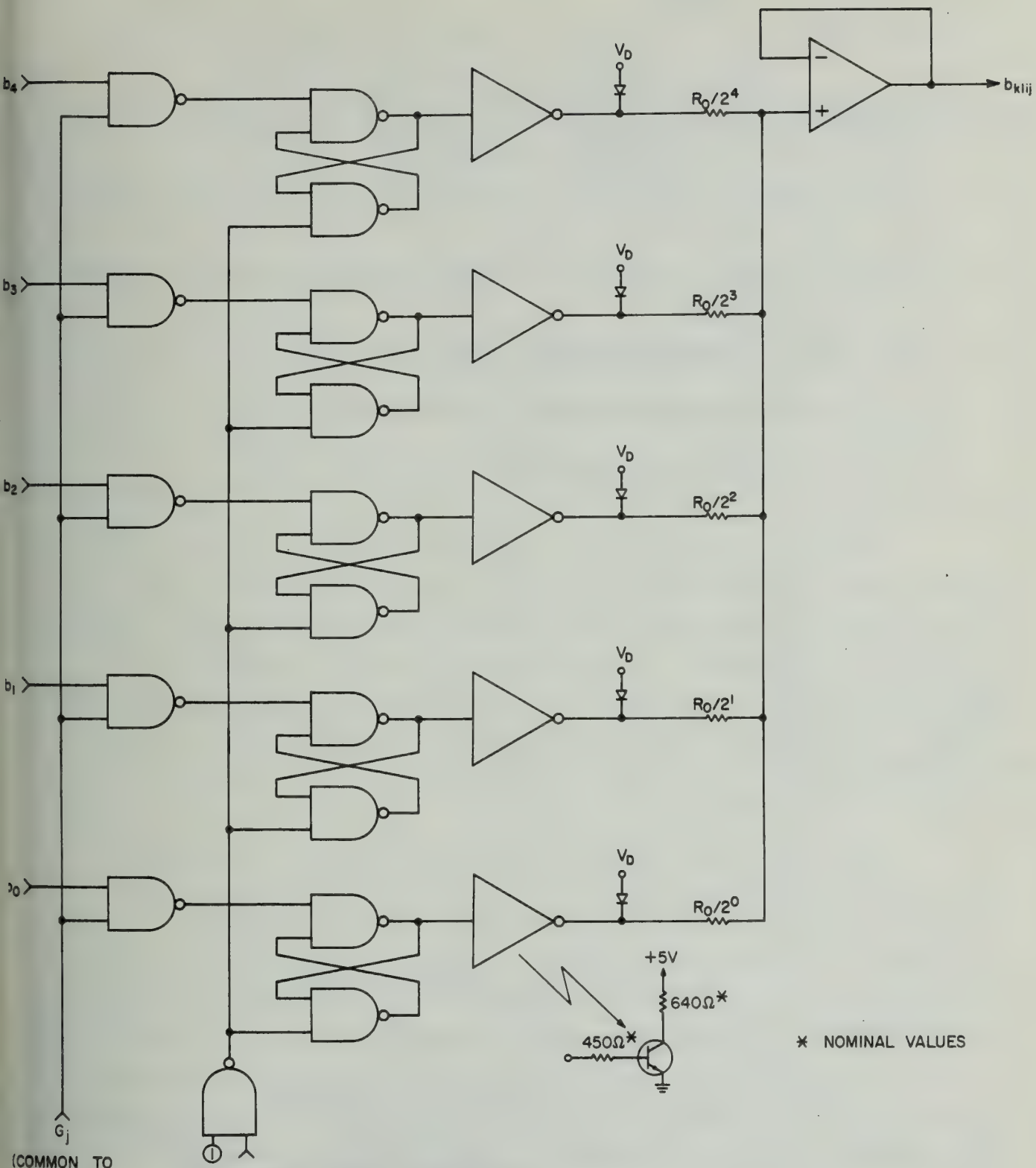
Each of the three transformations to be performed by TRANSFORMATRIX is characterized by a set of $(32)^4 = 1{,}048{,}576$ five bit coefficients. These coefficients are grouped into a set of 1,024 frames, with 1,024 coefficients per frame. Each frame of coefficients is generated on-line, 32 coefficients at a time in parallel (QTPR - OND - 1968), at the rate of 32 coefficients/100ns. In this way a set of 1,024 five bit registers receive one frame of coefficients in 3.2μs. Each five bit digital number is then converted into an analog voltage and compared against a clocked random analog voltage in order to produce its corresponding clocked random pulse sequence. Thus there is need for a circuit (to be reproduced 1,024 times) which will do the following:

1. Gate a five bit number into a storage register,
2. Store a five bit number, and
3. Convert the five bit number into an analog voltage.

The complete circuit is shown in Figure 6.

The gating and storage register are of straightforward design, the flipflops formed with two cross-coupled NAND gates. The Hex Inverter acts as a buffer for the binary weighted resistor ladder. The saturation voltage of the transistors in the Hex Inverter varies very little within any one package (less than 5mv) but the variation from package to package was as much as 87mv in a test of 20 units. For this reason the bumping diodes are needed to standardize the logical 0 output of the inverters.

The weighted resistor ladder feeding a high input impedance voltage follower was chosen over the more conventional weighted resistor ladder tied to the virtual ground of an op-amp, for the following reasons. Compared with op-amps of equivalent cost:



4	DM8000N	NATIONAL SEMICONDUCTOR TTL QUAD 2in NAND
1	MC889P	MOTOROLA RTL HEX INVERTER (5 CIRCUITS USED)
1	LM302	NATIONAL SEMICONDUCTOR VOLTAGE FOLLOWER

Figure 6. Digital Storage and D/A Conversion Circuit.

1. The voltage follower is at least ten times faster. For the configuration in Figure 6 and $R_O \approx 800K\Omega$, the voltage follower has an actual full scale slew rate of 10 volts/μs with no overshoot.

2. The input current, 30nA maximum, is less than or equal to most op-amps' offset current.

3. The offset voltage will be selected comparable to that of op-amps ($-10mv \leq$ Output-Input $\leq +5mv$).

4. The accuracy of the voltage follower (.15% dc) is not dependent on the accuracy of an external feedback resistor.

5. The output impedance of the voltage follower is extremely low, 2.5Ω maximum.

6. No external frequency compensation is required for the voltage follower.

Thirty-two such circuits, together with drivers, are placed on a single printed circuit board measuring $20\frac{1}{8}$" x $12\frac{1}{4}$". Thirty-two of these large boards will make up part of the TRANSFORMATRIX processor. Use of these boards has the advantage of reducing backpanel wiring, decreasing the parasitic capacitance the voltage followers have to drive, increasing reliability, lowering cost, and saving space: Considerable time was spent during this quarter in optimizing the layout of this board. The physical appearance of the board is shown in Figure 7.

The bumping diodes are selected into 32 groups of 5 x 32 = 160 diodes each plus spares according to forward voltage drop at a specified current. The Hex Inverters are selected into 32 groups of inverters each plus spares as a function of saturation voltage. Then a group of diodes and Hex Inverters are used to make up one board, with V_D individually adjusted for each board to obtain the same (00000) output for all 1,024 circuits.

The collector resistors of the Hex Inverters also vary considerably from unit to unit ($545.5\Omega \leq R_C \leq 822.2\Omega$ for a sample of 100 packages tested). This variation in R_C must be taken into account in selecting the ladder resistors. The basic equation used in determining the ladder resistors is derived from the circuit shown in Figure 8. The δ_i's include the effects of variation in collector resistor value from unit to unit, tolerance of ladder resistors, and temperature coefficient of ladder resistors.

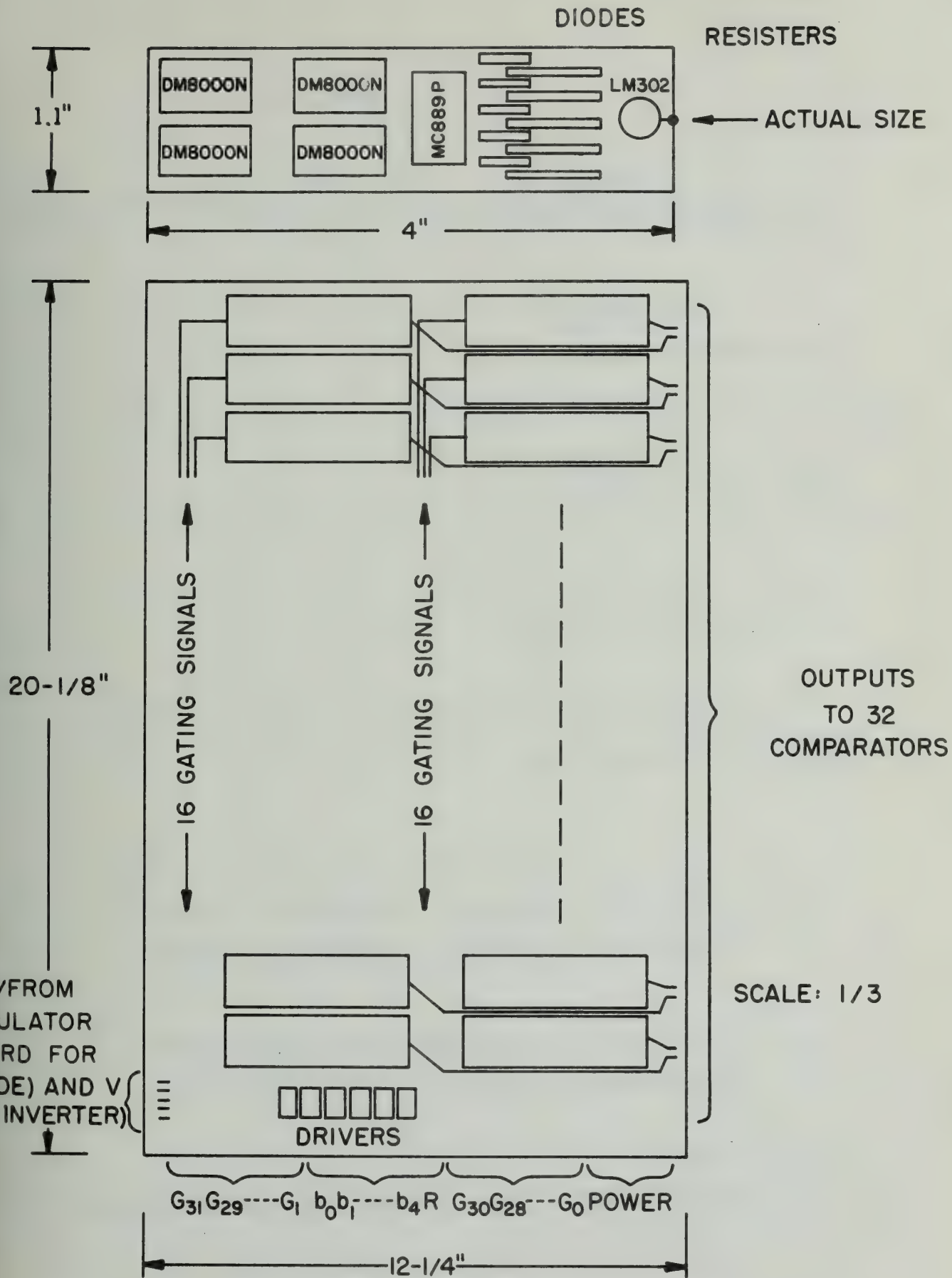
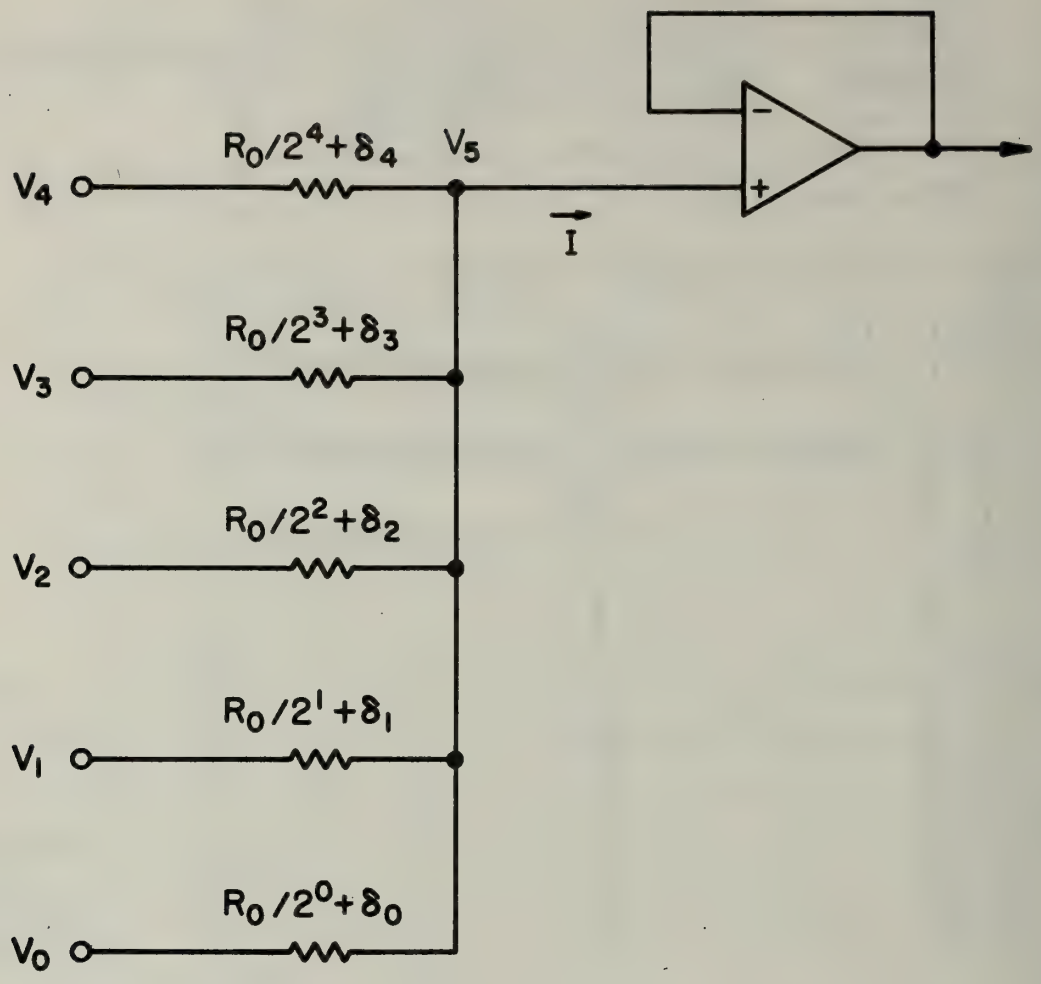


Figure 7. Physical Layout of Coefficient Storage and D/A Converter Board.



$$V_i = \begin{cases} V(1) \text{ FOR A LOGICAL 1 INVERTER OUTPUT} \\ V(0) \text{ FOR A LOGICAL 0 INVERTER OUTPUT} \end{cases}$$

$$\delta_i = \begin{cases} \delta_i(1) \text{ FOR A LOGICAL 1 INVERTER OUTPUT} \\ \delta_i(0) \text{ FOR A LOGICAL 0 INVERTER OUTPUT} \end{cases}$$

I = BIAS CURRENT FOR LM302 VOLTAGE FOLLOWER

Figure 8. Circuit for Determination of Ladder Resistors.

Summing currents at node V_S:

$$\frac{V_S - V_4}{(R_0/16 + \delta_4)} + \frac{V_S - V_3}{(R_0/8 + \delta_3)} + \frac{V_S - V_2}{(R_0/4 + \delta_2)} + \frac{V_S - V_1}{(R_0/2 + \delta_1)} + \frac{V_S - V_0}{(R_0 + \delta_0)} + 1 = 0$$

Rearranging terms and multiplying through by R_0 yields

$$V_S\left[\frac{1}{(1 + \delta_0/R_0)} + \frac{2}{(1 + 2\,\delta_1/R_0)} + \frac{4}{(1 + 4\,\delta_2/R_0)} + \frac{8}{(1 + 8\,\delta_3/R_0)} + \frac{16}{(1 + 16\,\delta_4/R_0)}\right]$$

$$= V_0\left[\frac{1}{(1 + \delta_0/R_0)}\right] + V_1\left[\frac{2}{(1 + 2\,\delta_1/R_0)}\right] + V_2\left[\frac{4}{(1 + 4\,\delta_2/R_0)}\right] + V_3\left[\frac{8}{(1 + 8\,\delta_3/R_0)}\right]$$

$$+ V_4\left[\frac{16}{(1 + 16\,\delta_4/R_0)}\right] - R_0 I$$

Using a first-order approximation for the denominators in the above expression (if δ_i/R_0 is small enough this will introduce negligible error) we obtain:

$$V_S\left[31 - \left(\frac{\delta_0}{R_0} + 4\frac{\delta_0}{R_0} + 16\frac{\delta_0}{R_0} + 64\frac{\delta_0}{R_0} + 256\frac{\delta_0}{R_0}\right)\right] = V_0\left(1 - \frac{\delta_0}{R_0}\right.$$

$$+ 2V_1\left(1 - 2\frac{\delta_1}{R_0}\right) + 4V_2\left(1 - 4\frac{\delta_2}{R_0}\right) + 8V_3\left(1 - 8\frac{\delta_3}{R_0}\right.$$

$$+ 16V_4\left(1 - 16\frac{\delta_4}{R_0}\right) - R_0 I$$

Dividing through by the term in the square brackets and using a first-order approximation again we have:

$$V_S = \frac{1}{31}[V_0 + 2V_1 + 4V_2 + 8V_3 + 16V_4] + \frac{1}{31}[(V_0 + 2V_1 + 4V_2 + 8V_3 + 16V_4) \cdot$$

$$(\frac{0}{R_0} + 4\frac{1}{R_0} + 16\frac{2}{R_0} + 64\frac{3}{R_0} + 256\frac{4}{R_0})] - \frac{1}{31}[V_0\frac{\delta_0}{R_0} + 4V_1\frac{\delta_1}{R_0} + 16V_2\frac{\delta_2}{R_0} + 64V_3\frac{\delta_3}{R_0} + 256V_4\frac{\delta_4}{R_0}]$$

$$- \frac{R_0 I}{31}[1 + \frac{1}{31}(\frac{\delta_0}{R_0} + 4\frac{\delta_1}{R_0} + 16\frac{\delta_2}{R_0} + 64\frac{\delta_3}{R_0} + 256\frac{\delta_4}{R_0}]$$

For $R_0 \approx 800K\Omega$ (maximum anticipated design value) and I = 30nA maximum, $\frac{R_0 I}{31}$ = .775mV. Thus the last term may be neglected as it is small and varies little for small changes in the δ_i's. It is seen that

$V_S(00000) = \frac{1}{31}[V(0) + 2V(0) + 4V(0) + 8V(0) + 16V(0)] = V(0)$

$V_S(11111) = \frac{1}{31}[V(1) + 2V(1) + 4V(1) + 8V(1) + 16V(1)] = V(1)$

exactly, as would be expected for a binary weighted resistor ladder feeding an infinite impedance voltage follower.

Several computer programming approaches are now being considered for the determination of an optimum set of ladder resistors.

Larry Ryan

2.5.6 D/A Converter Designed for the Output Display Subsystem

Two D/A converters are needed for the output subsystem to convert the x and y addresses into analog voltages before they are sent to drive the cathode ray display unit. Each of them has a 6-bit input and a settling time of two microseconds with a maximum output swing of about two volts.

Figure 9 shows the circuit schematic of a 6-bit digital to analog converter. The circuit consists of six analog switches and a weighted resistor summing network. The output of an analog switch is at the reference voltage level when its input is a logical "1". When its input is a logical "0", the output is grounded. The internal impedance of a switch is negligibly small compared with the load impedance. If the Norton Theorem is applied to the network shown in Figure 9, an equivalent circuit showing more explicitly

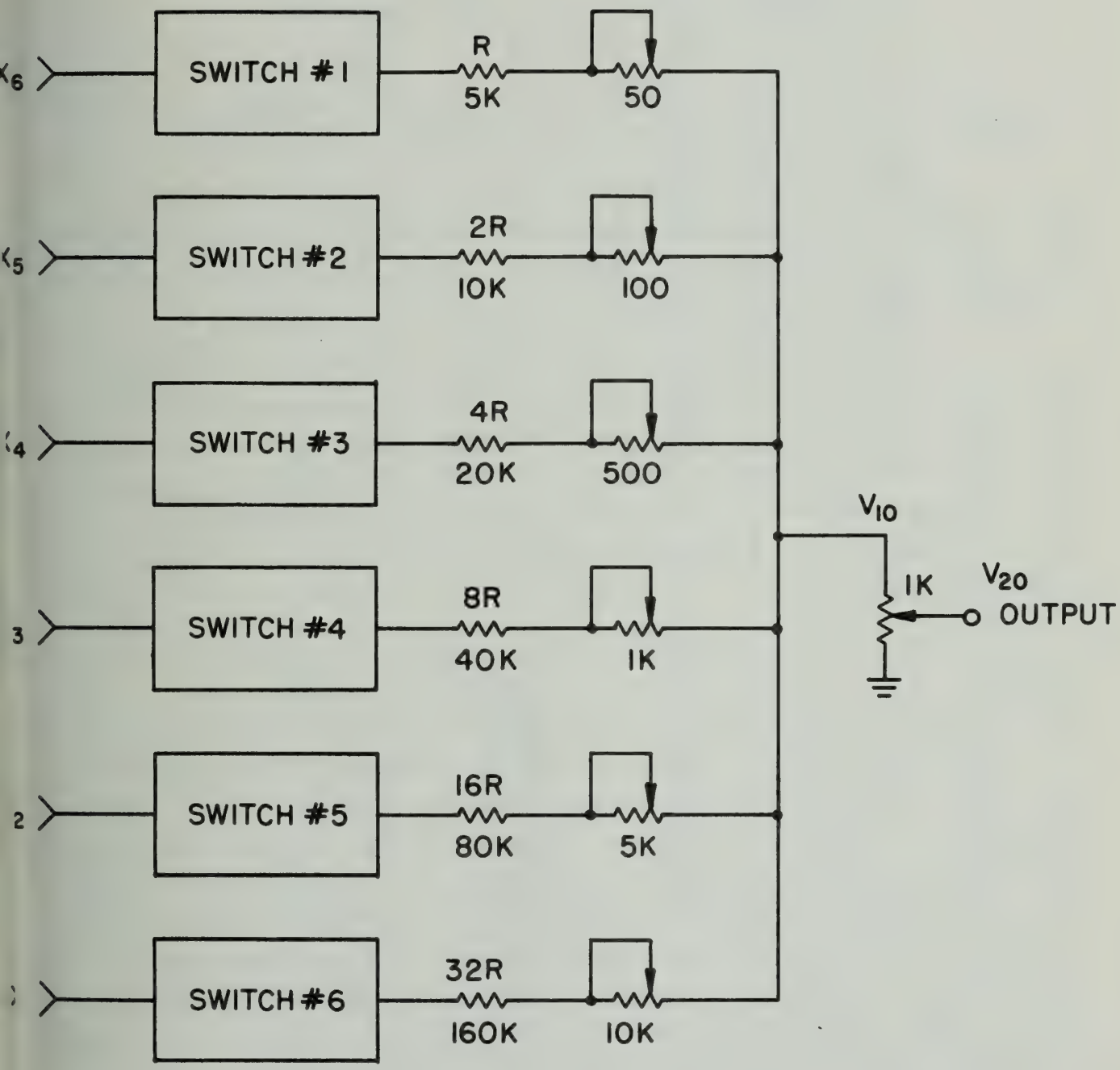


Figure 9. Six Bit D/A Converter.

the digital to analog convertion function results. This is Figure 10, which shows clearly the combined equivalent current source is given by

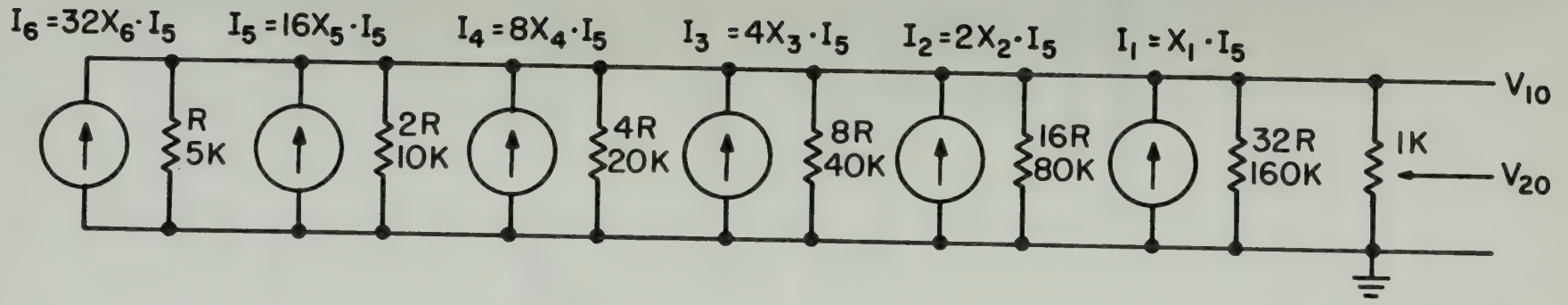
$$I_T = \frac{V_{ref}}{160k\Omega}(2^5x_6 + 2^4x_5 + 2^3x_4 + 2^2x_3 + 2x_2 + x_1)$$

It follows that the output voltage V_{10} or the attenuated output V_{20} is proportional to the value of the 6-bit binary number of the input.

Trimming potentiometers are used in series with each input branch. This is to provide customized adjustment for eliminating errors due to the non-zero output impedance of the voltage switch as well as the deviation in resistance value from the given one due to tolerance.

It is well known that resistance changes with temperature. This temperature effect would cause serious error for the converter if it is not taken care of properly, especially with the higher significant bit circuit. To ensure accurate conversion over the entire temperature range of operation, metal film and wire wound resistors with low temperature coefficients are therefore used in the key places such as the weighted resistors of higher significant bits.

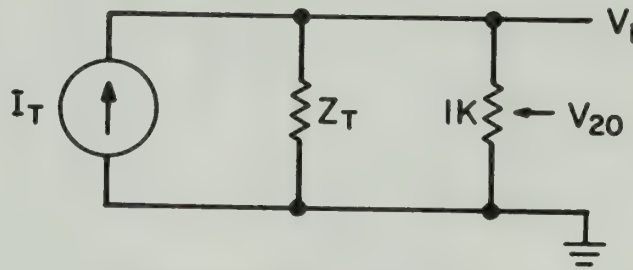
The circuit diagram of the analog voltage switch is shown in Figure 11. A buffer amplifier stage is employed in the switch output network to insure that the signal swing is larger than the reference voltage of 12 volts. The output of the buffer stage is DC coupled to the complementary pair 2N1308 and 2N1309 through the current limiting resistors of R5 and R6. The transistors 2N1308 and 2N1309 are operated in an inverted mode configuration. This is because transistors have small collector to emitter saturation voltage in such a configuration and it leads to smaller off-set error of the digital to analog converter. The emitter of the transistor 2N3642 returns to -2.5 volts, which is provided by a forward biased diode device SV3163A. Being forward biased at 25mA through the resistor R_4, the device has an exceptionally low dynamic internal impedance of about 5 ohms and a forward drop of 2.5 volts. To lower the internal impedance of the -2.5 volts supply further, C1 and C2 are connected in parallel with the SV3143A. C3 is a solid tantalum type



X_i IS THE LOGIC VALUE OF THE i^{TH} BIT INPUT

$$I_5 = \frac{\text{REFERENCE VOLTAGE}}{160K}$$

(a) NORTON EQUIVALENT OF THE WEIGHED RESISTOR NETWORK



$$I_T = (32X_6 + 16X_5 + 8X_4 + 4X_3 + 2X_2 + X_1) I_5$$

$$Z_T = 160K \| 80K \| 40K \| 20K \| 10K \| 5K$$

$$= \frac{160K}{63} = 2.54K$$

(b) REDUCED EQUIVALENT CIRCUIT

Figure 10. Norton Equivalent of the Converter Circuit.

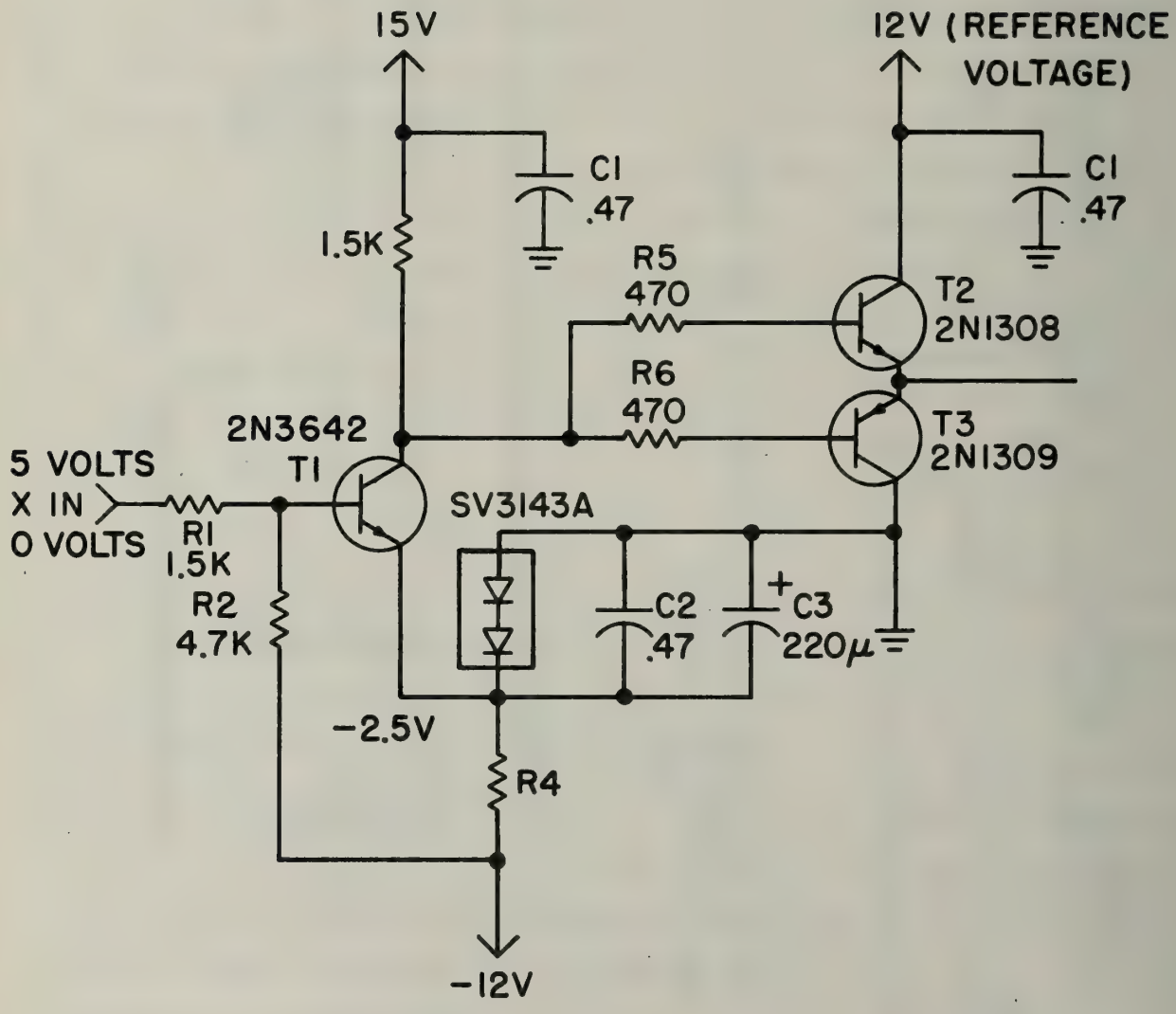


Figure 11. Analog Voltage Switch.

capacitor of high capacitance for low frequency harmonic filtering while C2 is ceramic type high frequency capacitor. The resistor chain R_1 and R_2 is used to hold the base of 2N3642 at about -3 volts to insure the 2N3642 being cut off when the input X_{in} is at logic level "0". When transistor T_1 is off, the collector base junctions of the 2N1308 and 2N1309, both operated in inverted mode, are forward and reverse biased respectively. Hence, the 2N1308 is turned on while the 2N1309 is off, causing the output to be held at the reference voltage of 12 volts. Similarly, the output is grounded when T_1 is turned on. It should be noted that the emitter base junction of the transistor T_3 is reversed biased at 3 volts when T_1 is off. Hence, transistor T_3 is required to have an emitter base breakdown voltage of more than 3 volts. The same requirement is needed for transistor T_2 as a result of a similar argument for the case in which T_1 is on.

An experimental sample of this converter has been built and has shown satisfactory performance. A printed circuit version of this converter is now being made.

Yui Wo

2.6 STEREOMATRIX Project No. 30

2.6.1 Observer Position Detector

As described previously, ultrasound was being considered as a means of detecting the observer's position. The 30kHz frequency required a relatively large resonant transducer and was highly attenuated in air. These limitations rendered 30kHz unacceptable for this position detection application. The frequencies of 300kHz and 500kHz were evaluated and though range was improved, performance remained unacceptable. Frequencies about 500kHz posed additional problems.

At this point, an evaluation of a radio frequency or microwave scheme as a practical solution is necessary. The most promising possibilities are phase detection and high speed delay time measurements.

Chuck Pirnat

2.6.2 Coefficient Generator

The overall logic design on the coefficient generator is completed. Final drawings will not be done until more investigation and decisions are made on some details such as up-dating time, speed of operation and control systems.

After investigating more than twenty-three different makes of core memories, the PDM-17 by Data-Ram Corporation was chosen and ordered. It is a 4K x 12 bit random access core memory with 3μs read-write cycle time. The unit includes data register, data retainer and all TTL logic circuitry.

Many digital to analog converters were investigated. Computer Products' DA425A was bench tested and the findings are better than the specifications from the manufacturer. It has an output voltage ± 10.23v at 10mA, settling time less than 50μs (14μs was measured), accuracy ± 0.1% and the stability is very good. Since each converter is on a 2.75" x 4" printed circuit board, it is required to assemble the twelve channel D/A converter together with references in a standard 19" rack assembly. The D/A converters and reference power supplies arrived recently.

A list of TTL integrated circuits was submitted for approval to order. They are various gates, adders, counters, flipflops, shift-registers, and multiplexers, amounting to somewhat more than two thousand IC's.

One of the more difficult problems is to put sine and cosine functions into the core memory of the coefficient generator. Paper tapes can mostly supply 8 bits in parallel, and the speed is very slow. A magnetic tape unit is planned to store the output from 360/75 and then transfer it into the core memory.

Digital indicating devices were also investigated. At this time the nixie flickering and high voltage requirement are undesirable. But the seven-segment has a problem of uneven display intensity. More investigation is underway.

2.6.3 Cursor

The cursor is used by the operator to locate the coordinates of a point in the 3-D space of the stereomatrix display system. When the cursor coincides with a desired point on a graph, a pulse is sent back to the computer. A block diagram of the raw design of the cursor system is shown in Figure 1. The cursor image generator and coincidence detector is shown in Figure 2.

2.6.4 Stereomatrix System Design

Surveys were made to investigate the power requirements, space requirements, ventilation, controls, and indicating devices on the control console. The general layout and the control console design were discussed and temporarily approved by the group (Stereomatrix).

The overall block diagram of the Stereomatrix is shown in Figure 3. The control console is shown in Figure 4, A, B, and C.

Dick Cheng

2.6.5 STEREOMATRIX Transformer

This quarter has been devoted to procuring, testing and designing hardware needed for the transformer.

Since this unit requires a very fast analog multiplier and divider, the Motorola multiplier, MC1595, has been wired with an op-amp level shifting network and tested up to 200kHz. However, our system requires a speed of 2 - 3 MHz, and thus the Hybrid Systems multiplier model 105 has been obtained.

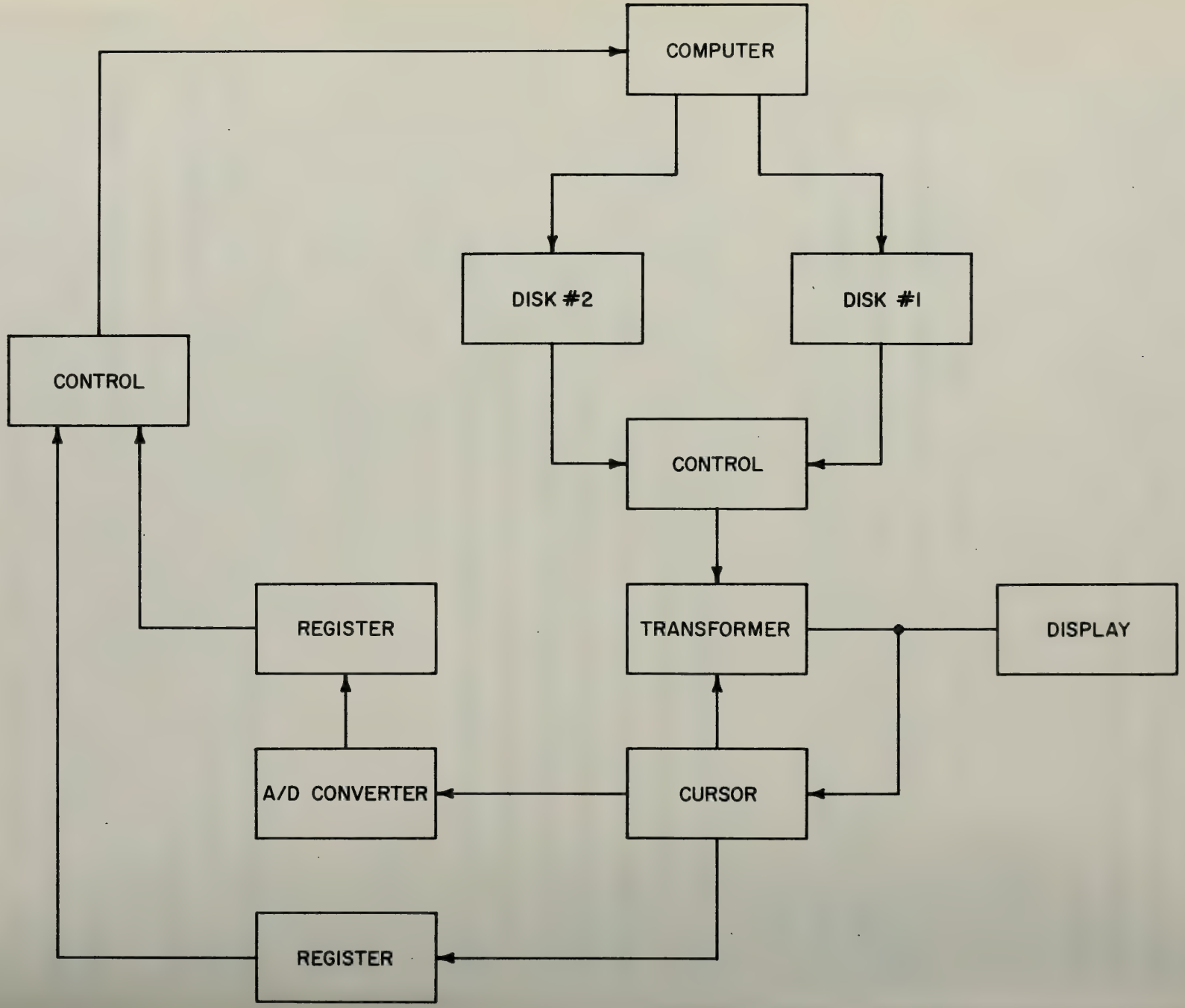


Figure 1. Cursor Block Diagram.

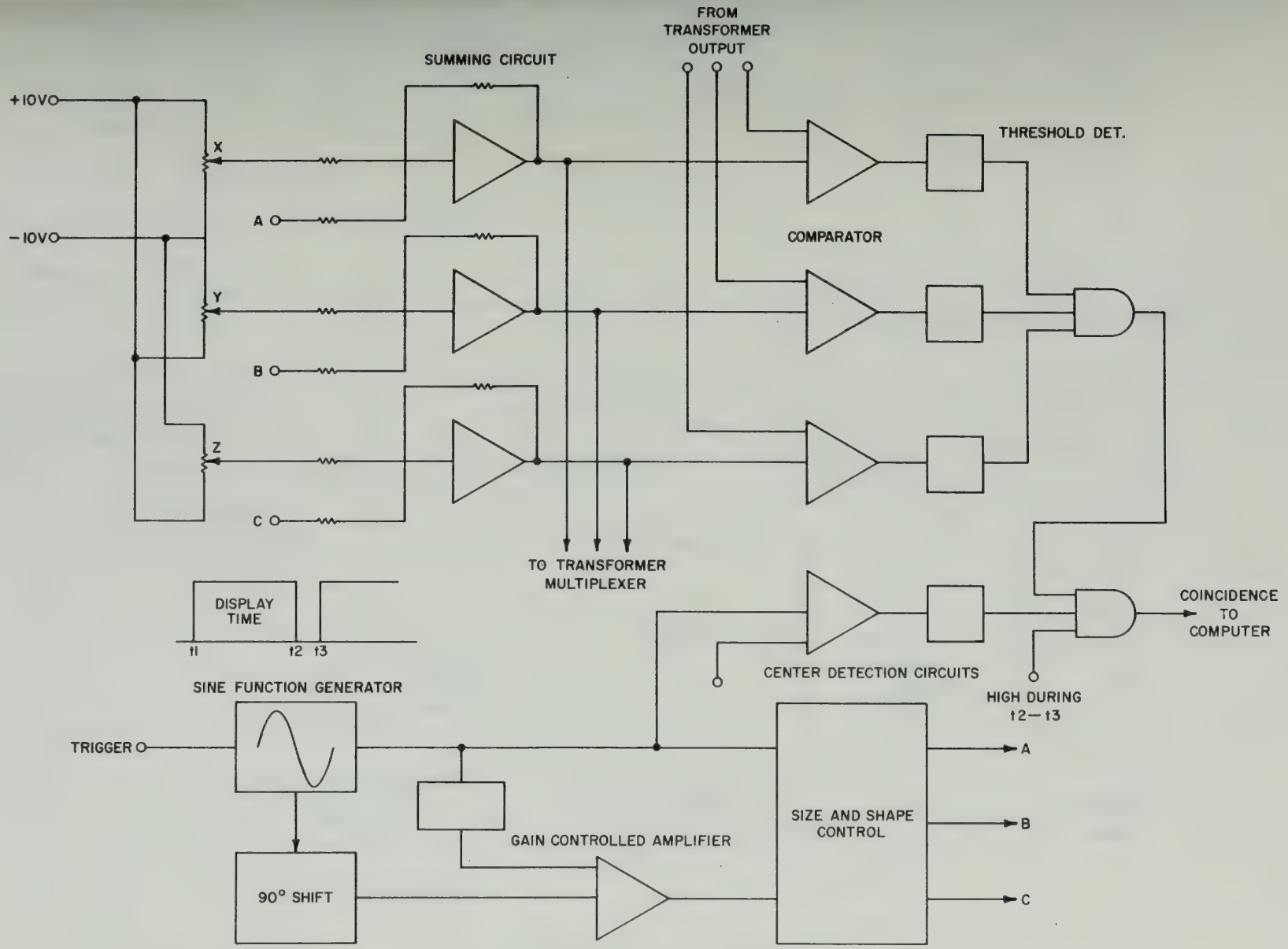
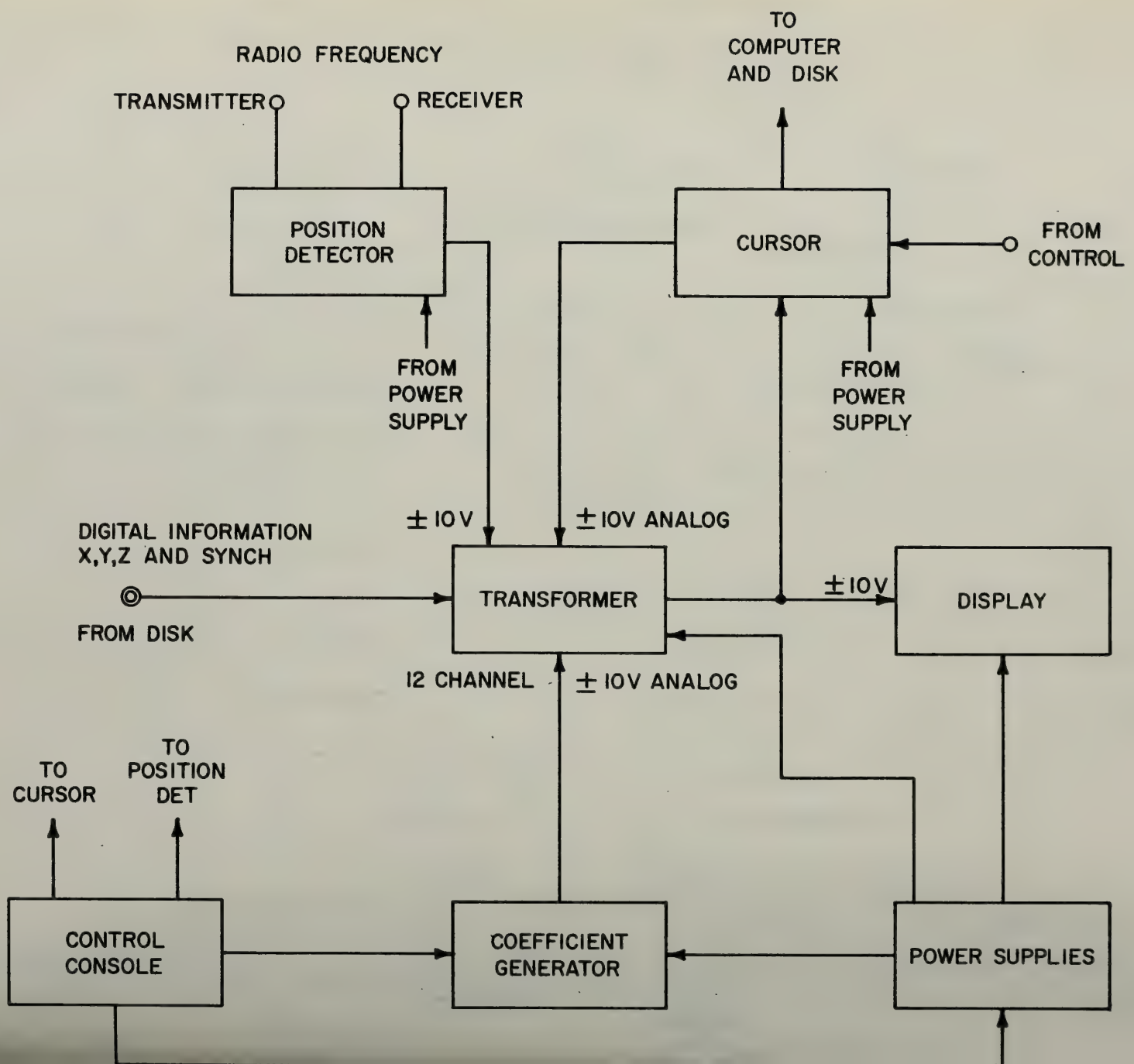


Figure 2. Cursor Circuit.


RADIO FREQUENCY
TRANSMITTER
RECEIVER
TO COMPUTER AND DISK
POSITION DETECTOR
CURSOR
FROM CONTROL
FROM POWER SUPPLY
FROM POWER SUPPLY
±10V
±10V ANALOG
DIGITAL INFORMATION X,Y,Z AND SYNCH
TRANSFORMER
±10V
DISPLAY
FROM DISK
12 CHANNEL
±10V ANALOG
TO CURSOR
TO POSITION DET
CONTROL CONSOLE
COEFFICIENT GENERATOR
POWER SUPPLIES

CABINET

A. POSITION DETECTOR AND CODER

B. CONTROL DEVICE, COUNTER AND POWER SUPPLIES

C,D. COEFFICIENT GENERATOR

E,F. STEREO TRANSFORMER

G,H. LASER DRIVER AND AMPLIFIER

* ALL CABINETS ARE STANDARD 19" RACK MOUNTING, 4' IN HEIGHT.

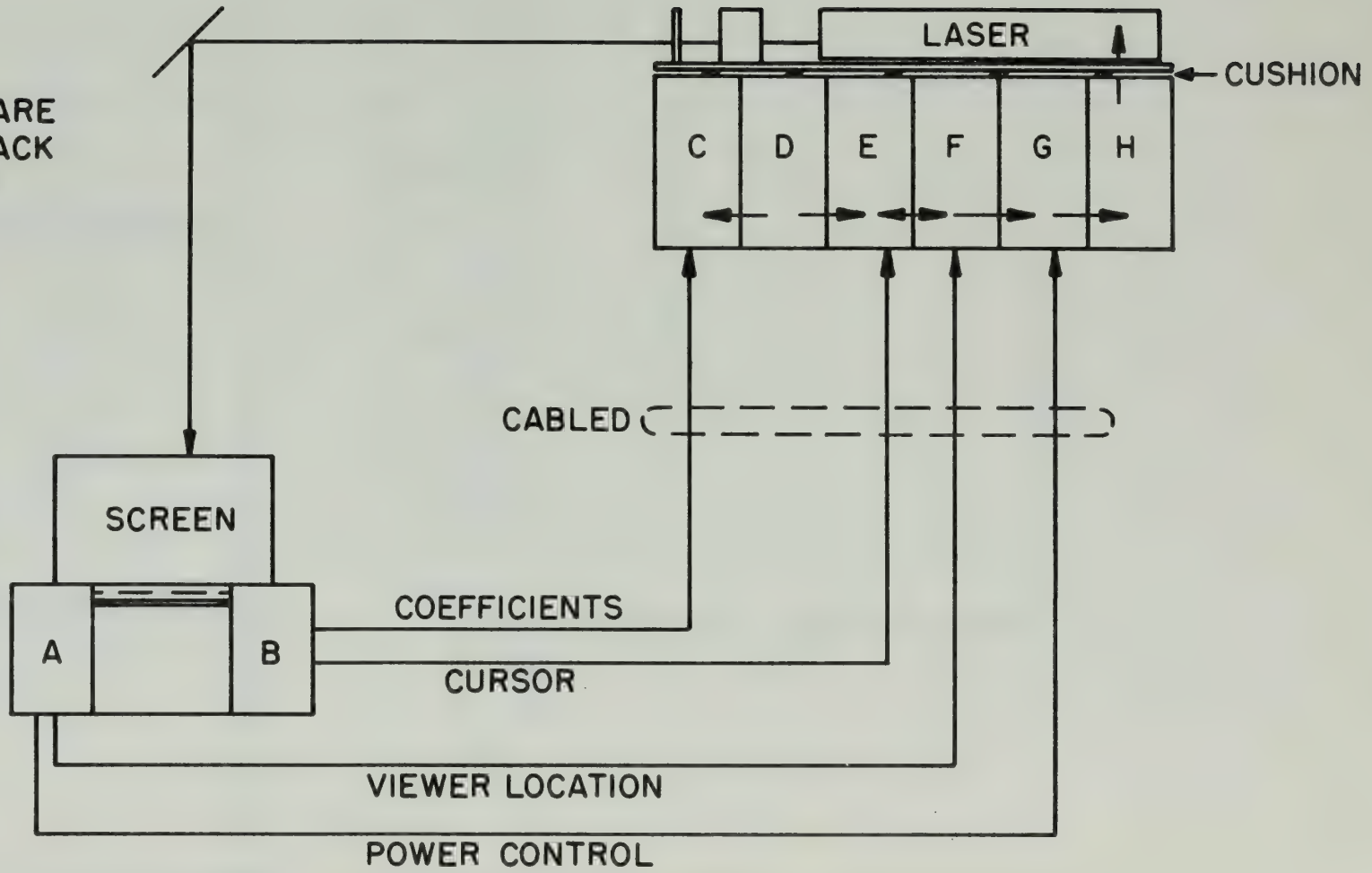


Figure 4A. Stereomatrix General Layout.

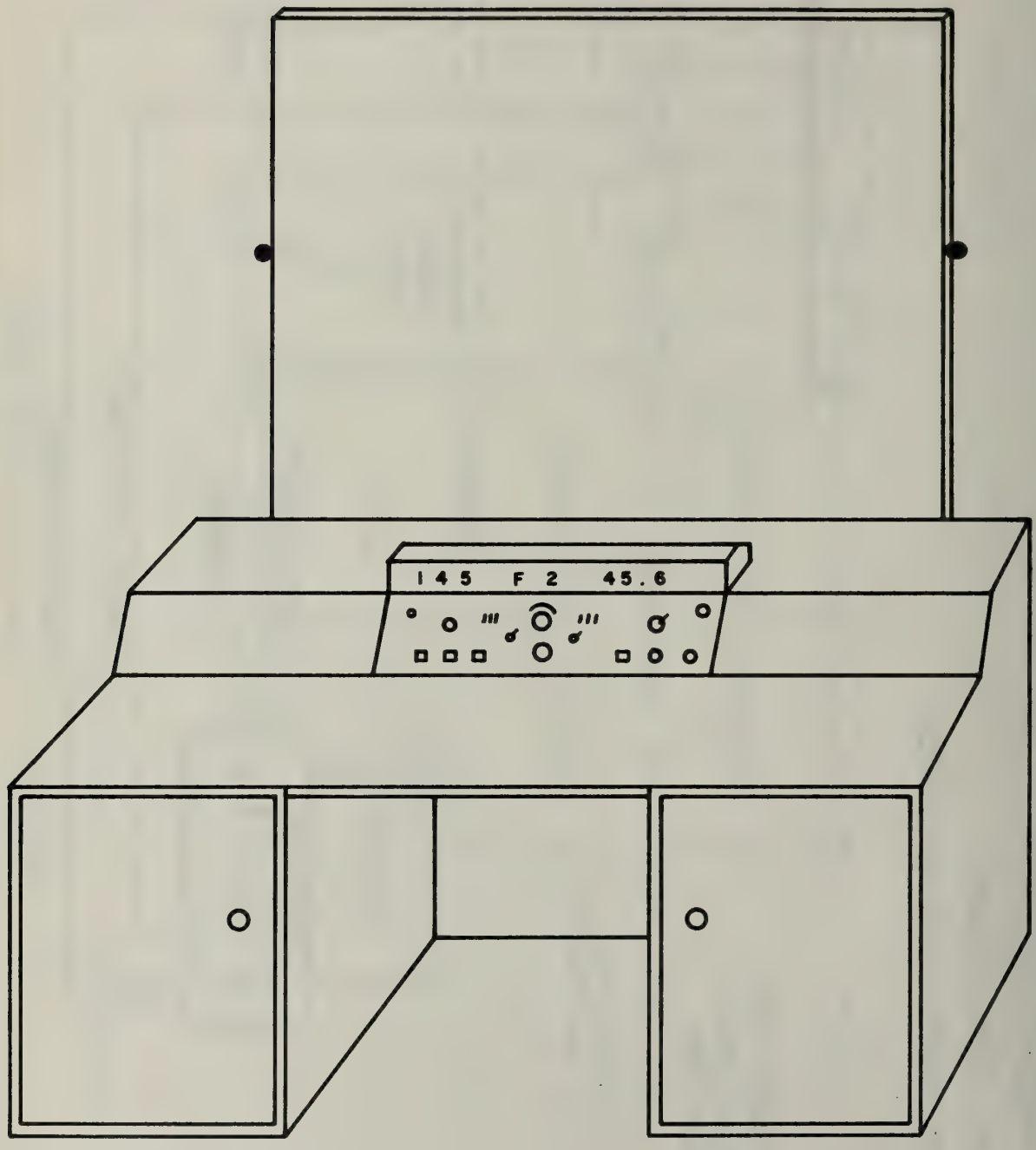


Figure 4B. Control Console and Screen.

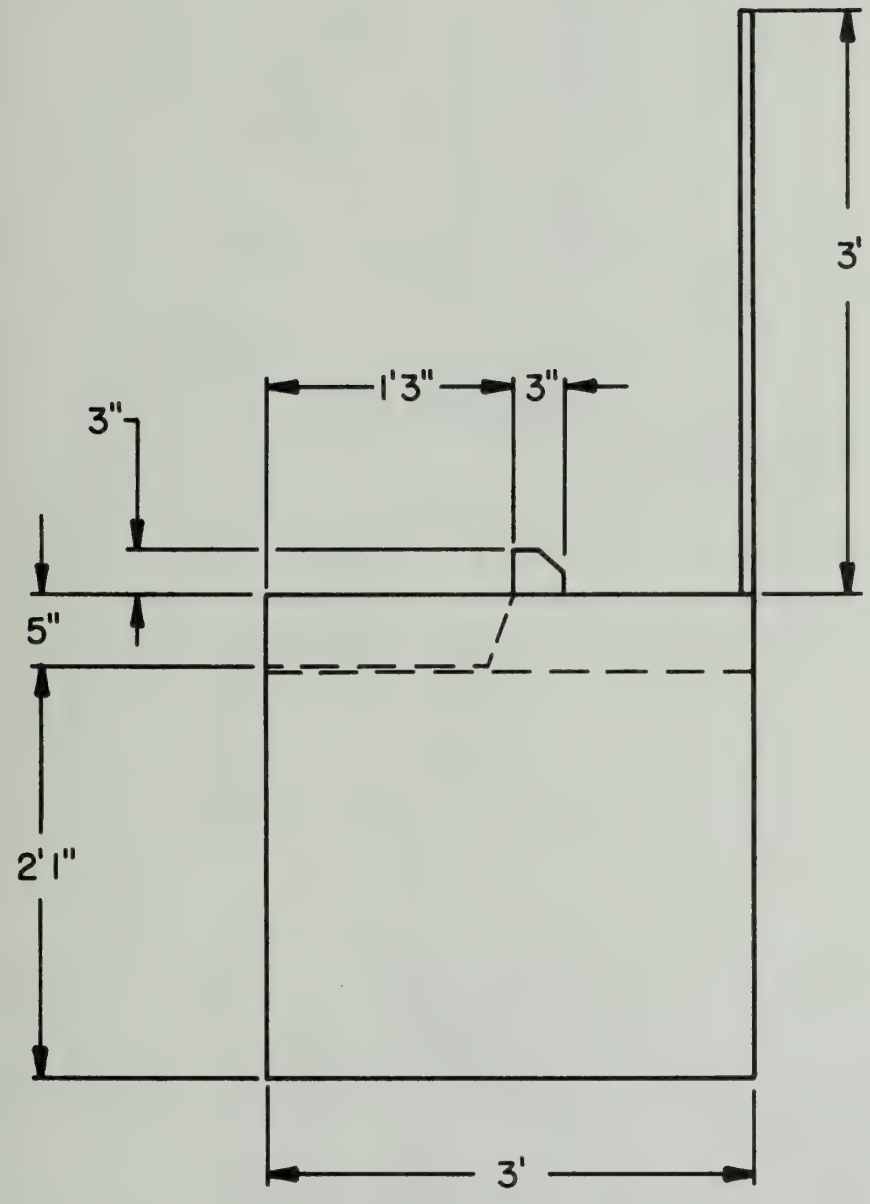


Figure 4C. Control Console, Side View.

It has been tested satisfactorily up to 10MHz and its stability is very good. It gives a maximum error of 1%, when the signals to be multiplied are of the order of millivolts. However, when the input signals are large, the error in multiplication is almost zero in all the quadrants.

Further, we need quite a few operational amplifiers. Hence, Analog Device operational amplifier models 120 and 220B were tested and found satisfactory up to 10MHz for a gain of 10. However, for gain greater than 10 and with a large feedback resistor, the frequency response of the op-amp is not good.

The Hybrid System multiplier 105 was used with an Analog Device op-amp model 120 as a four quadrant divider (Figure 5). The result from the divider is that the output is of inverted polarity in two cases as shown in the table of Figure 6. In the case where the output polarity is inverted, either the output or one of the inputs must be inverted externally to get the correct sign. This situation is due to the stability restriction in the division configuration. The limitation of this circuit is bandwidth. It has been noted that the bandwidth is a function of the Y input. When the Y input is between 5 volts and 10 volts, it works up to 10 MHz and for the Y input less than 5 volts, this becomes very slow. The possible reason for this is that the op-amp has a non-linear resistance in its feedback path, and for small "Y" it gives a large resistance, which increases the gain of the op-amp and, thus, the bandwidth goes down. In order to get rid of this problem, an op-amp which has a larger bandwidth than the multiplier has been ordered.

An R-2R network for the D/A converter has been ordered. An analog gate which can switch a +10v to -10v signal has been designed (Figure 7) and tested up to 5MHz. However, the FET transistor 2N4222 has an ON resistance of 300 ohms and gives an offset voltage of 3 volts when $\pm$ 10 v is switched. Thus, an FET with small ON resistance has been ordered. Further, a transistor faster than a 2N1305 is ordered to improve the switching speed of the analog gate. A fast switch for a bipolar D/A converter is being designed.

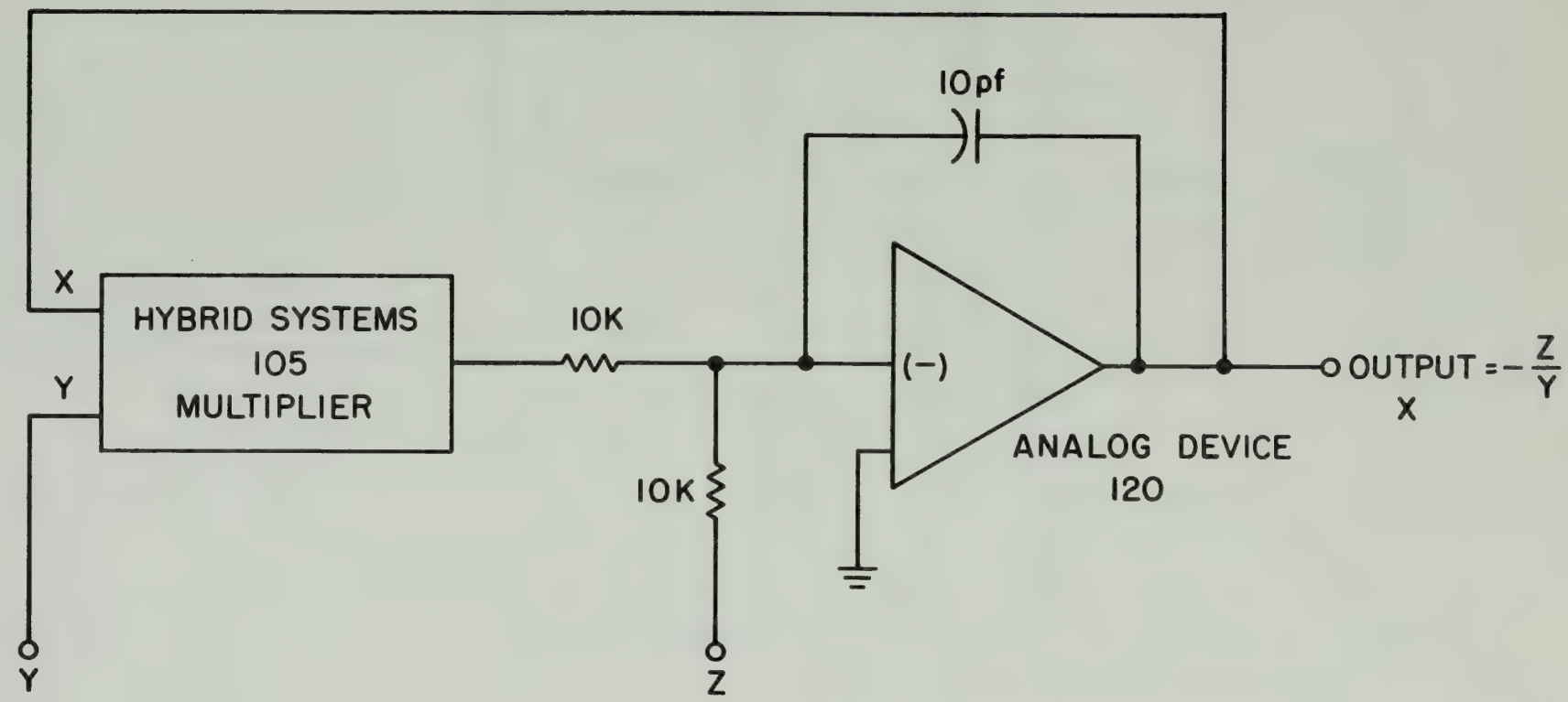


Figure 5. Analog Divider.

Y	Z	E_{OUT}	COMMENT
+	+	−	$E_{OUT} = \frac{-Z}{Y}$
+	−	+	$E_{OUT} = \frac{-Z}{Y}$
−	−	+	$E_{OUT} = \frac{Z}{Y}$
−	+	−	$E_{OUT} = \frac{Z}{Y}$

Figure 6. Output Table for Four Quadrant Divider.

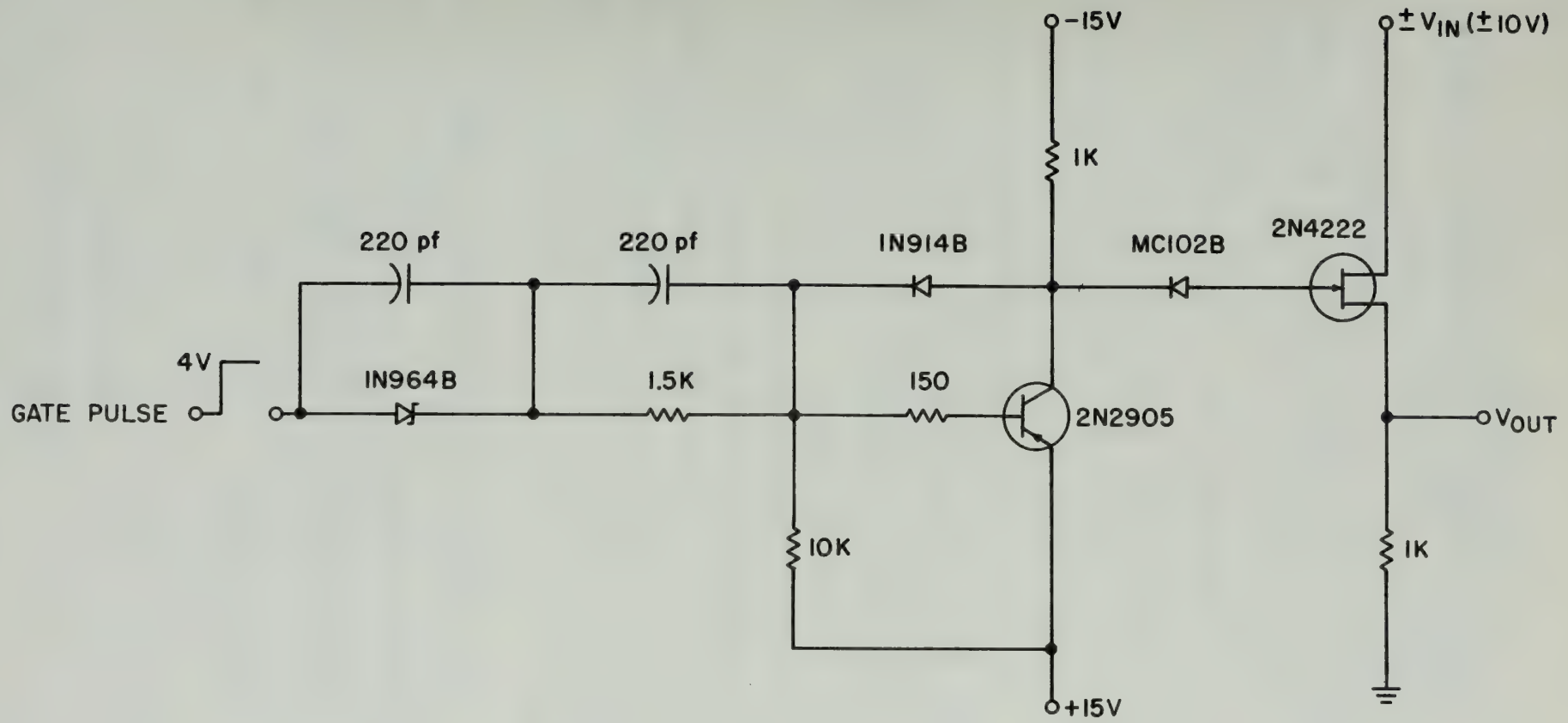


Figure 7. A 5MHz Analog Gate.

It has been decided that the transformer will have its own power supplies: +20v - 8Amp, -20v - 8Amp and 30v - 3Amp.

Considering the cost of the analog multiplier and the fact that quite a few of them are needed in this system, it has been decided to build a fast 10MHz multiplier. Hence, after the analog gate and D/A converters are tested, work will begin on the design of a fast multiplier. In the meantime, layout of the transformer cards, etc., has started.

Shiv Verma

2.6.6 The Display

Specifications for the ultrasonic deflectors were completed and proposals have been received for evaluation. The best proposal specifies an access time of about seven microseconds. For our system to operate at the 1.5MHz rate planned (60 frames/second) we needed an access time of 467 nanoseconds. The seven microseconds figure seems to be about the state-of-the-art for ultrasonic deflection at this time. This limitation is imposed by the velocity of sound in the deflector material, the physical size of the deflector, and the power handling capabilities of the transducer. The most promising deflector material is lead molybdate with a lithium niobate transducer.

At this point there are several alternatives. We may continue pursing random access and reduce frame rate to 30 frames per second with resultant flicker, decrease deflector cell length by one-half with resultant loss of light intensity, and increase of the spot size, or we may introduce a cathode ray tube with an observing TV camera between the transformer and the display to convert the random transformer output into a raster scan. This possibility is being studied.

Steve Whiteside

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3. COMPUTER SYSTEMS RESEARCH

This work was supported in part by the Department of Computer Science, University of Illinois at Urbana-Champaign, Urbana, Illinois, and in part by the U. S. Atomic Energy Commission under grant U. S. AEC AT(11-1)1469, Part A.

Reports Written

1. Hostovsky, R. Design of a Display Processing Unit in a Multi-Terminal Environment, Department of Computer Science Report No. 343, University of Illinois, Urbana, Illinois, and submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer Science.

2. Michel, M. GRAPHICAL REMOTE-ACCESS SIMULATION SYSTEM (GRASS) The Communication and Monitor Components (GASP/GLASP), Department of Computer Science Report No. 346, University of Illinois, Urbana, Illinois, and submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer Science.

3.1 Ordinary Differential Equations (K. Ratliff)

ODESSY Update: As a result of feedback from users of ODESSY, some changes in the package are indicated. Many of these problems involve user input errors which are not anticipated by the compiler and therefore are not interpreted properly. Several of the suggested improvements have already been added to the program and a new version of ODESSY will be produced upon completion of the alterations.

The matrix inversion program for sparse matrices has been rewritten and debugged. Economy of storage space is a primary aim of the new version. In the selection of pivot elements and the symbolic inversion, much information must be temporarily stored and used for evaluating the characteristics of an element at several points in these processes.

The array containing the matrix and its original characteristics is also used to store this additional information as it is accumulated. Chains of elements with a common characteristic (pivot, eliminated, etc.) are used to avoid searching the entire matrix for an element with the given characteristic.

Subroutines to perform the actual arithmetic associated with the elimination process have been written. After a pivot element has been chosen, there is a symbolic rearrangement of the matrix based on the elimination process. During the rearrangement these subroutines are used to change the numerical value of the matrix elements affected.

3.2 Graphics

3.2.1 DEC 338 Software (C. Hyde)

The new generalized drawing routine (FLOG) is the result of an attempt to minimize the number of memory swaps needed to process a series of interrupts from a console. In a minimal system of one console the problem of memory allocation does not pose any major difficulties. With the addition of one or more other consoles, however, the problem of switching between consoles leads to excessively long response times unless steps are taken to prevent this.

Since certain drawing functions, such as drawing an invisible line, require no change in either the display file or the data structure of a picture, these two bodies of information do not have to be brought into memory if there is a small area of core allocated to each console which can be used to store information. However, if the users at several consoles are using different programs to process their input, response time still lags since programs may not be in core at the times they are needed. To overcome this problem, the system shown in Figure 1 is being implemented.

Each console is associated with a console vector which describes the state of that console and contains information to be processed by a program associated with that console.

The state of a console is determined primarily by a group of five words in the console vector (Figure 2). These words contain the addresses of routines in the program associated with the console, which process the interrupts from the console. The five types of interrupts which may occur are joystick (light pen), push button, keyboard, manual interrupt, or system. The system interrupt is a signal that a function, initiated by the program, but which could not be completed immediately by the system routines (e.g., information retrieval), has been completed. The six words of X,Y information contained in the console vector are used to determine where a joystick interrupt is indicated on the console display screen (Figure 3). By calling a simple subroutine, the program can determine whether to ignore the interrupt (e.g., a hit in area A) or to process the interrupt (e.g., a hit in area B).

The core save/restore word is used to indicate, to the system, that either the data structure or the display file or both are to be saved on the disk or restored from the disk. In cases where the program never refers to either of these data sets, this word is effectively ignored.

The work area of the console vector has a format which is determined by the program and the general purpose drawing routines package. Typical information retained in this area is: the last visible X,Y point on the drawing area, the current X,Y position of the joy stick, and indicators which determine which drawing routines are to be executed in the drawing routines package.

The program, in this case FLOG, may be shared by several console vectors and therefore must be serially reusable. FLOG does not ever directly modify either the data structure or the display file. The routines needed to update these data sets are contained in the general purpose drawing routines package. An attempt is being made to keep the package as general as possible. This will allow other programs (such as text editors) to be implemented in a simple manner.

The data structure is represented by a series of blocks, the first being a header block which contains the starting addresses of the following blocks (Figure 4). The header block also contains user supplied information, in this case the names of variables associated with different node types in this picture.

The node block (Figure 5) contains the position and type information for every node on the drawing. Nodes may be marked as internal or external and may be included in the picture as the result of attaching a subpicture. When attaching a subpicture, nodes in that subpicture which are marked as internal are not transferred to the node block of the current picture.

The line drawing block (Figure 5) contains all lines which have been explicitly drawn by the user.

The equation and parameter blocks (Figure 6) contain the equations, supplied by the user, that will be used to analyze the model being formed, and the parameters of these equations. A typical equation might be: E(2) = E(1) + I(1)*R with R being the parameter for this equation. Parameters are not extracted from the equations by the drawing routines and must therefore be supplied by the user.

The subpicture block (Figure 7) contains the name and position of each subpicture attached by the user.

The connection table (c.f. Figure 8) contains entries which specify the interconnection of nodes. Connectors may be directed or non-directed and may also be either visible or invisible. Connections are formed by FLOG when a subpicture is attached to a node on the picture. All other connections must be specified by the user.

A change table entry (c.f. Figure 9) is made when the user indicates that a parameter must be changed for analysis. The parameter to be changed may be in a subpicture at any level of nesting of subpictures.

The global and internal variable lists (Figure 10) are supplied by the user for use by the analysis programs. No processing of these lists is performed by FLOG.

Figure 1

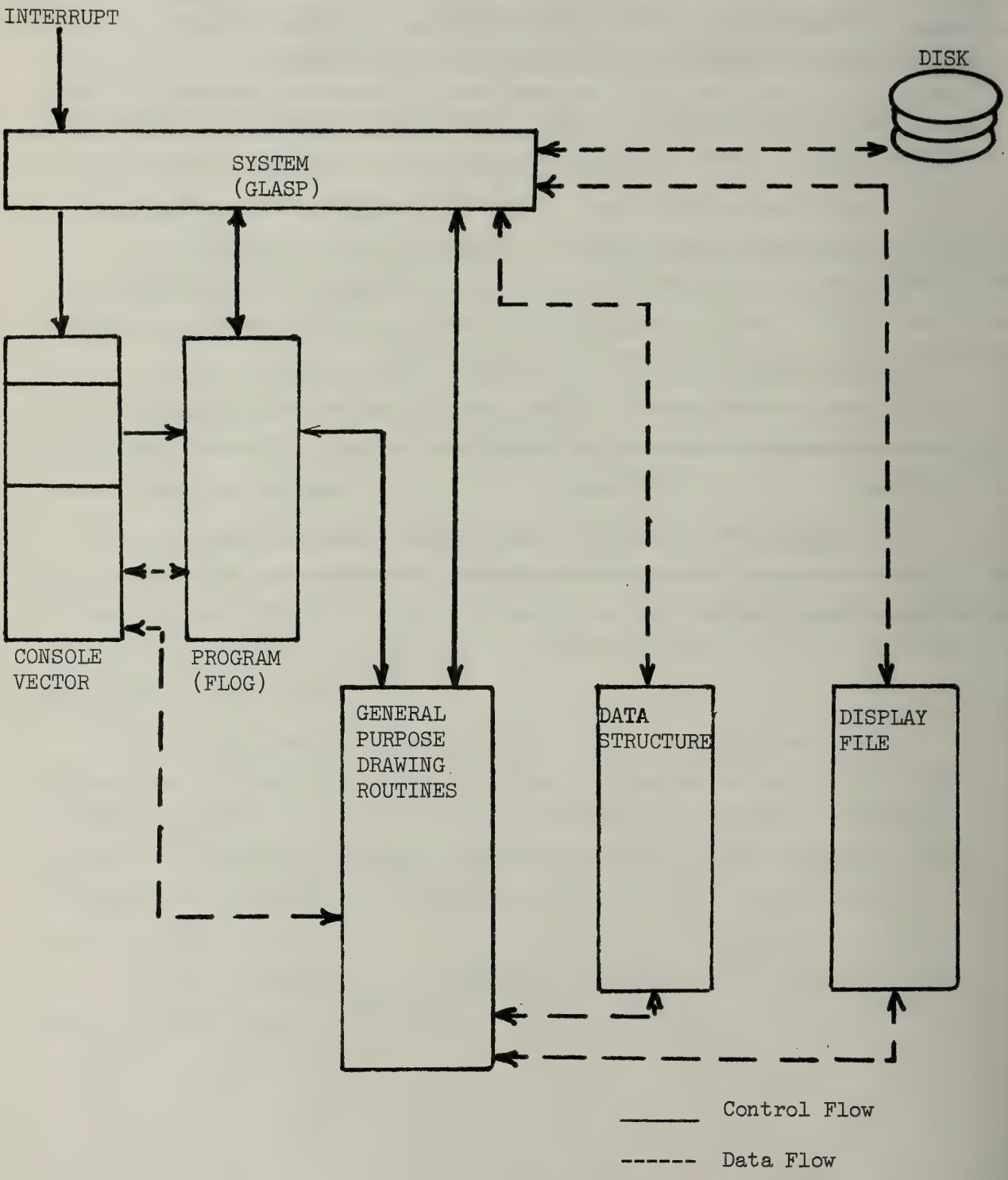
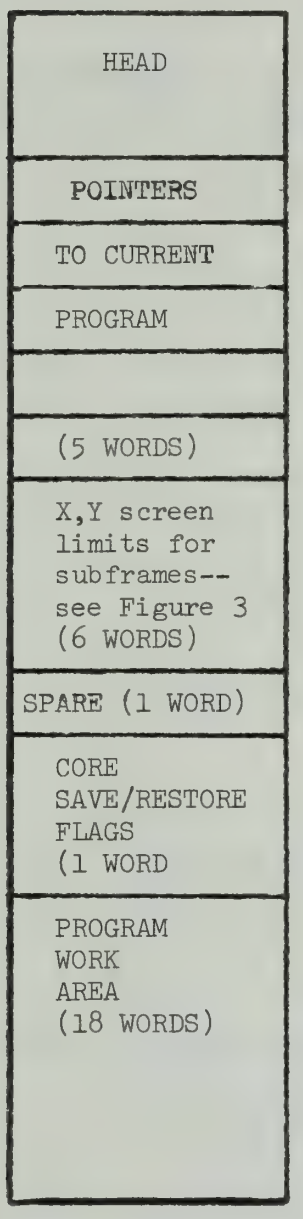

INTERRUPT
DISK
SYSTEM
(GLASP)
CONSOLE
VECTOR
PROGRAM
(FLOG)
GENERAL
PURPOSE
DRAWING
ROUTINES
DATA
STRUCTURE
DISPLAY
FILE
Control Flow
Data Flow

Figure 2

CONSOLE VECTOR

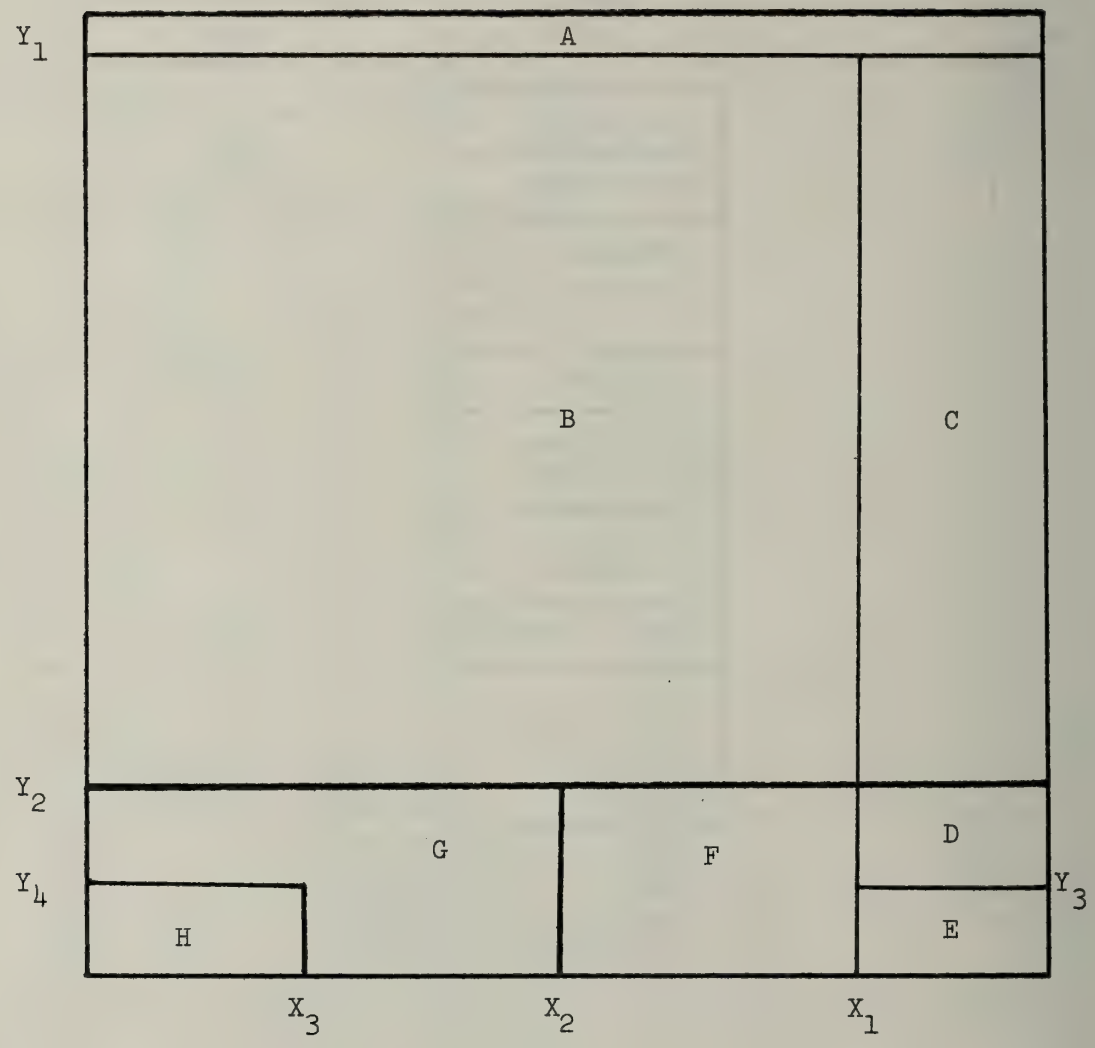


HEAD--reserved for system use

ONE PER CONSOLE

Figure 3

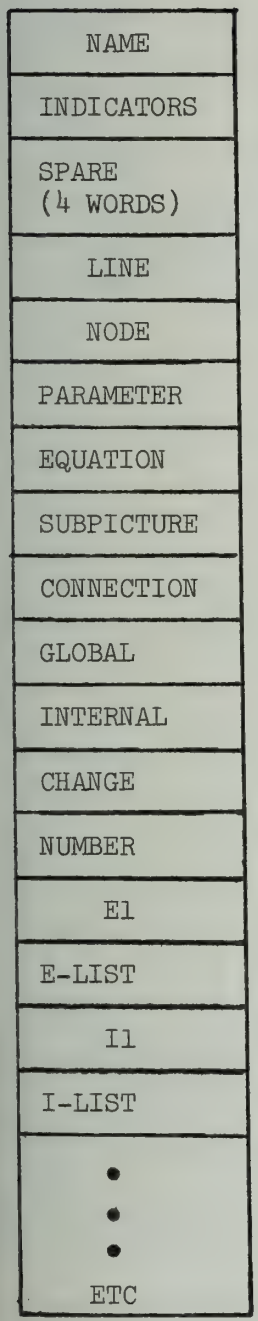
SCREEN LAYOUT



A - SYSTEM MESSAGE AREA
B - DRAWING AREA
C - SUBPICTURE NAME AREA
D - YES/NO
E - ANSWER AREA
F - LIGHT BUTTONS
G - PROMPTING AREA
H - PANIC BUTTON

Figure 4

DATA STRUCTURE HEADER BLOCK



NAME - INTERNAL NAME OF THIS PICTURE (2 WORDS)

INDICATORS - USED TO ESTABLISH THE PICTURE TYPE (1 WORD)

LINE - ADDRESS OF THE LINE BLOCK (1 WORD)

NODE - ADDRESS OF THE NODE BLOCK (1 WORD)

PARAMETER - ADDRESS OF THE PARAMETER LIST (1 WORD)

EQUATION - ADDRESS OF THE EQUATION LIST (1 WORD)

SUBPICTURE - ADDRESS OF THE SUBPICTURE TABLE (1 WORD)

CONNECTION - ADDRESS OF THE CONNECTION TABLE (1 WORD)

GLOBAL - ADDRESS OF THE GLOBAL VARIABLE LIST (1 WORD)

INTERNAL - ADDRESS OF THE INTERNAL VARIABLE LIST (1 WORD)

CHANGE - ADDRESS OF THE CHANGE LIST (1 WORD)

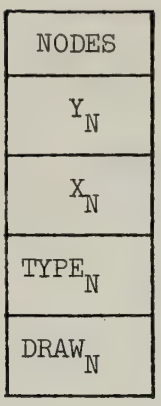
NUMBER - NUMBER OF NODE TYPES (1 WORD)

E1 - NUMBER OF WORDS OF E-TYPE ONE VARIABLE TEXT IN E-LIST (1 WORD)

E-LIST - TEXT OF E-TYPE ONE VARIABLE ASSIGNMENT (E1 WORDS)

Figure 5

NODE BLOCK/LINE DRAWING BLOCK



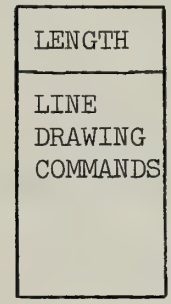
NODES - NUMBER OF NODES IN THE PICTURE (1 WORD)

Y_N - Y POSITION OF THE N-TH NODE (1 WORD)

X_N - X POSITION OF THE N-TH NODE (1 WORD)

$TYPE_N$ - TYPE OF THE N-TH NODE (1 WORD)

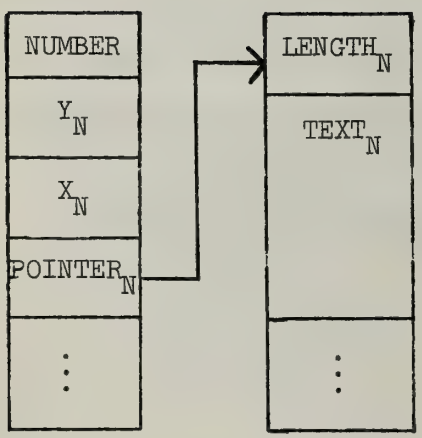
$DRAW_N$ - ADDRESS OF THE NODE GENERATING TEXT IN THE LINE DRAWING BLOCK OR THE NUMBER OF THE SUBPICTURE IT BELONGS TO (1 WORD)



LENGTH - LENGTH OF THE LINE DRAWING BLOCK (1 WORD)

Figure 6

PARAMETER/BLOCK EQUATION



NUMBER - NUMBER OF PARAMETERS (EQUATIONS) (1 WO

Y_N - Y POSITION OF THE N-TH ($\frac{\text{PARAMETER}}{\text{EQUATION}}$) (1 WORD

X_N - X POSITION OF THE N-TH ($\frac{\text{PARAMETER}}{\text{EQUATION}}$) (1 WORD

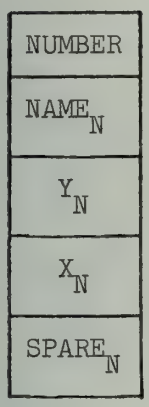
$POINTER_N$ - ADDRESS OF THE N-TH ($\frac{\text{PARAMETER}}{\text{EQUATION}}$) TEXT BLOCK (1 WORD)

$LENGTH_N$ - LENGTH OF THE N-TH PARAMETER TEXT BLOCK (1 WORD)

$TEXT_N$ - THE N-TH PARAMETER TEXT BLOCK

Figure 7

SUBPICTURE BLOCK



NUMBER - NUMBER OF SUBPICTURES (1 WORD)

$NAME_N$ - INTERNAL NAME OF THE N-TH SUBPICTURE (2 WORDS)

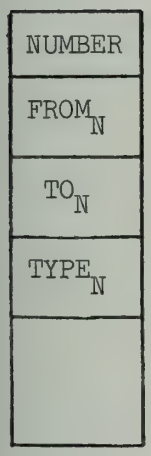
Y_N - Y POSITION OF THE N-TH SUBPICTURE (1 WORD)

X_N - X POSITION OF THE N-TH SUBPICTURE (1 WORD)

$SPARE_N$ - UNUSED (4 WORDS)

Figure 8

CONNECTION TABLE



NUMBER - NUMBER OF CONNECTIONS (1 WORD)

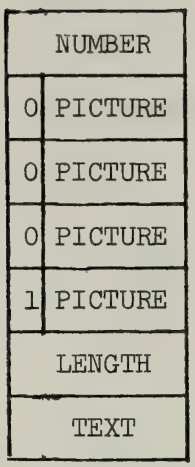
$FROM_N$ - ORIGIN OF THE N-TH CONNECTOR (1 WORD)

TO_N - TERMINUS OF THE N-TH CONNECTOR (1 WORD)

$TYPE_N$ - TYPE OF THE N-TH CONNECTOR (i.e., visible, invisible, etc.) (1 WORD)

Figure 9

CHANGE TABLE



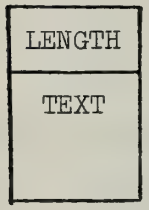
NUMBER - NUMBER OF ENTRIES IN THE CHANGE TABLE

PICTURE - IF BIT ZERO IS ZERO, PICTURE IS THE NUMBER OF A SUBPICTURE OF THE CURRENT PICTURE OR THE PREVIOUS SUBPICTURE ON THIS LIST. IF BIT ZERO IS A ONE, PICTURE IS THE NUMBER OF THE PARAMETER TO BE CHANGED.

LENGTH - LENGTH OF FOLLOWING TEXT (1 WORD)

Figure 10

INTERNAL AND GLOBAL LISTS



LENGTH - LENGTH OF THE TEXT IN WORDS (1 WORD)

3.2.2 Graphics Monitors (M. Michel)

The monitor (GASP) for the 360 end of the simulation system is about 95% coded. However, the failure-to-materialize of several scheduled and necessary software and hardware modifications to the service area 360/50-75 operating system (namely, OS-MVT release 17, PLORTS modifications, bulk core storage, and 2701-PDA) has prevented the check out and completion of this monitor.

The interaction of the PDP8 monitor (GLASP) and the general drawing and data structure handling package is in the final stages of definition (c.f. 3.2.1 DEC 338 Software). The overall design of the information retrieval component is also under discussion.

Several routines to test the 2701-PDA high speed data link have been coded, but the PDA has not yet been delivered by IBM.

Disk check out (by Harold Levin) is proceeding, with several hardware modifications being suggested as a result. These include the use of parity bits for hardware error detection and word counters to allow accessing of N words beginning at the K-th word on any sector (i.e., unaligned variable length block accessing).

3.2.3 FPL/II (S. Wilkins)

3.2.3.1 Current Status

FPL/II flowchart input is still being simulated with data from cards since the PDP8/360 interface is not yet completed. However, the simulated input format has been changed from the card oriented format to the continuous string input format which the interface will eventually provide.

The subflowchart call routines have been written to allow flowcharts to call other flowcharts as subroutines. The ability to pass parameters has been incorporated in the call routines. All variable name parameters are called by name while constants are passed by value.

To increase the string manipulation facilities of FPL/II, the following proposal is under consideration:

```
Let CS1 = 'CARSTRING1'
    CS2 = 'GOSTRING'
CS3 = CS1 + CS2 = 'CARSTRING1GOSTRING'  concatenation of char strings
```

In order to select portions of a character string

1. Let CSN + FIX = character string "CSN" - the number of characters represented by the fixed point variable "FIX" deleted from the left

   ex: CS3 + 4 = 'TRING1GOSTRING'

   if FIX = 10
   CS3 + FIX = 'GOSTRING'

2. Let CSN - FIX = character string "CSN" - the number of characters represented by the fixed point variable "FIX" deleted from the right

   ex: CS3 - 10 = 'CARSTRIN'

   ex: Let left = 3
   Let right = 6
   then CS1 + Left = 'STRING1'
   CS1 - Right = 'CARS'
   CS1 + Left - Right = 'S'
   CS1 + (Right - Left) = 'STRING1'
   CS1 + (Left - Right) = 'CARSTRI'

3. Let CSN(LEN) be the fixed point number that is the length of the character string CSN.

3.2.3.2 Forthcoming Plans

For the general purpose simulation system currently in the design stage there will be a generalized conversion program operating in the S/360. This program will accept data structures from the PDP8 which

represent networks and equations defined on the display screen and convert the equations into forms suitable for input to various proposed analysis programs.

1. Up-Analysis - This routine will convert the PDP8 data structure into a suitable list representation.

2. Down-Analysis - Using the lists generated by the Up-Analysis this routine will generate the equations and variables for the analysis program.

3. Symbolic Manipulator - A string analysis routine this will actually handle all equations: check syntax and the validity of variables associated with nodes and prepare the string output that will be input to the analysis programs.

3.3 PLORTS Timesharing System (A. Whaley, J. Christopher, P. Boekhoff)

The PL/I system, which has been undergoing continuous revision, has solidified in the completion of Pass II this quarter. Each of the various statement types and internal data structures has been completely resolved, and is herein described. The discussion involves only those features of the language not sufficiently explored in the IBM reference manual.

A few programming errors in the FILE DSP have been found and corrected.

The first draft of a manual for the PL/I system has been written.

The filing system was completely rewritten this quarter. It has now operated for several months with only one failure, which appears to have been related to hardware or operator malfunction.

3.3.1 Pass II SYMBOL Routine

This routine includes three entry points--SYMBOL, BLOCK, and SYMFIND. These are discussed in reverse order here.

SYMFIND is entered with the (virtual) displacement of a symbol table entry in register 0, and returns the actual core address of the entry in register 1. If there is no such entry, register 1 is set to zero.

BLOCK creates a block table entry. The first call to BLOCK does a GETMAIN for the table, zeros the entire area, and places its address in the MASTER table. The calling sequence is:

```
LA  0,TYPE
CALL BLOCK
```

where TYPE is one of the following:

1 - DO type 1
2 - DO type 2
3 - DO type 3
4 - BEGIN

5 - PROCEDURE

6 - IF

7 - ELSE

Each time a block is opened in Pass II a call is made to BLOCK to create an appropriate entry and to point BLKCURNT, the first halfword of the table, to this new entry. The format of an entry is as follows:

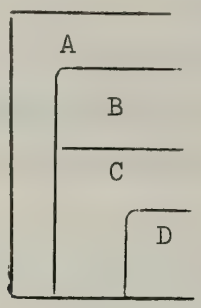
```
BLKPACKP   DS   H      Displacement of predecessor, zero for
                      first entry
BLKFORWP   DS   H      Displacement of successor, zero for
                      last entry
BLKFLAGS   DS   X      Type code (1 - 7)
BLKLEVEL   DS   X      Nest level number for this block
BLKSTPNT   DS   H      Virtual symbol table displ for
                      first symbol
BLKHWCNT   DS   X      Number of halfword internal-label
                      entries to follow
BLKNMCNT   DS   X      Number of 8-character labels to follow
BLKINTLB   DS   OH
```

This is followed by a halfword for each internal label (e.g., labels to be resolved when END is encountered), then by any labels attached to the block. BLOCK sets BLKHWCNT according to the type of block, but does nothing about the labels (BLKNMCNT is set to zero, and BLKFORWP points to the location following the last internal-label halfword). Thus the caller (the statement routine--DO, BEGIN, etc.) must first call BLOCK, then check labels himself. For each label, the 8-character name must be placed in the location pointed to by BLKFORWP, then FLKNMCNT must be increased by 1 and BLKFORWP by 8.

When a block is closed (e.g., an END statement is found, or the end of an IF is reached) the block table must be popped by creating a new entry for the next outer block, and BLKCURNT pointed to it. This is accomplished thusly:

```
SR  0,0
CALL BLOCK
```

There is a block table entry for each block each time it is structurally entered. That is, for the program structure



there would be 7 entries: A, B, A, C, D, C, A. The level number of each entry will differ by one from its predecessor and from its successor.

The format of the symbol table entries has been modified into what appears to be its final format:

```
SYMCATGY    DS    X
SYMFORM     EQU   X'F0'    Form of entry:  variable, constant, etc.
SYMCMPLX    EQU   X'08'    = 1 if complex
SYMDIMEN    EQU   X'04'    = 1 if dimensioned
SYMTYPE     EQU   X'03'    Type of variable, constant, or file
SYMLNGTH    DS    X        4 or 8 for constant, string length, etc.
SYMCATG2    DS    X
SYMALLOC    EQU   X'80'    Storage allocated
SYMSTORG    EQU   X'60'    Auto/static/controlled
SYMDECL     EQU   X'10'    Explicitly declared
SYMFILE     EQU   X'08'    FILE
SYMDPREC    EQU   X'04'    = 1 if double precision
SYMPHONY    DS    X        Used internally by SYMBOL
SYMPOINT    DS    H        Virtual displacement of data
SYMDATA     DS    0X       Name, value, etc.
```

The revision to this format and to the logic of the SYMBOL routine was occasioned by the decision not to require DECLARE statements to be at the top of the block.

A call to SYMBOL from Pass II (indicated by a bit in the call; Pass III will also use SYMBOL) for a named item (variable, external name, label, etc.) is handled as follows:

First a check is made to see if a symbol table exists. If not, a GETMAIN is issued for a symbol-table segment, whose format is:

```
SYMBACKP   DS    F        Preceding segment
SYMFORWP   DS    F        Succeeding segment
SYMDISPL   DS    H        Virtual displ of first entry in
                          this segment
SYMDISP2   DS    H        Virtual displ of last byte used
                          in this segment
SYMAREA    DS    CL1012   Space for symbol table entries
```

and this first segment is initialized with SYMBACKP=SYMFORWP=0, SYMDISPL=2 (a handy conversion), and SYMDISP2=1. The slot in MASTER called NXTAVSYM (next available virtual SYMTAB location) is also set to 2. The entry is now added to the symbol table.

If the table does exist, a search is made of that part (or those parts--see block table description above) of the symbol table corresponding to the current block. If no entry is found, one is created in the current block. If one is found, SYMDECL is checked in that entry and in the one being passed in the call to SYMBOL. If both bits are on, a multiple declaration is flagged (Return Code = 12) and SYMBOL exits to the caller. If SYMDECL is on in the new one, the attribute data is moved into the table, since the item is now being declared. If SYMDECL is not on, SYMBOL exits.

For constants, the symbol table is searched sequentially without reference to the block table. If the constant is not found, it is added (again in the current block, but this is incidental) with SYMDECL set.

If the item is a label pointer, it is added to the table (in the current block). The label pointer is a rather strange entry: bytes 1 and 2 contain the program and level number; bytes 4 and 5 (SYMPOINT), the current contents of the Polish location counter. As one might suspect,

these are created by the LABEL routine: for a labeled statement, a label pointer entry is generated, and the symbol table entries for all labels on the statement point (SYMPOINT) to this entry (entries for the labels have SYMDECL set if they are not subscripted).

When it encounters a symbol-table reference, Pass III will check SYMDECL. If it is off, the item has not been declared in this block. Pass III will then search outward for an occurrence of the same name with SYMDECL set; if none exists, the variable will be declared in the outermost block. The program is then modified to point to the declared entry. This search therefore takes place at most once at any point in the program.

SYMBOL is called as follows:

```
LA   2,Parameters
CALL SYMBOL
```

and returns with

```
 0 = Virtual displacement of entry
 1 = Actual core address of entry
15 = Return Code:
     0 - Found in symbol table
     4 - Not found; new entry added
     8 - Table overflow ( 65K)
    12 - SYMDECL on but already declared
```

The contents of Parameters in the call:

Byte 0	Option flag (Pass II/III)
1 - 3	Address of search argument
4 - 6	First 3 bytes of SYMTAB entry: SYMCATGY, SYMLNGTH, SYMCATG2

3.3.2 Pass II Statement Routines

The halfword internal-label pointers in the block table will be discussed with the respective statement routines; their meanings are outlined here for reference.

CODE	STMT	#	USE
1	DO_1	0	
2	DO_2	2	LV*, LY
3	DO_3	2	LV*, LY
4	PROC	5	L1,LDO,LD'(current),LDE'*,L2(flush list)
5	BEGIN	5	--,LDO,LD'(current),LDE'*,L2(flush list)
6	IF	1	L1
7	ELSE	1	L2

* already defined

3.3.2.1 PROCEDURE Statement

a. Statement label constant L1 is generated but not defined.

Output: [L1] [Branch] (all output is Polish)

b. Entry names: a call to SYMBOL is made for each.

c. Block table entry: constructed for type PROCEDURE. The L1 pointer and the 8-character entry names are output into the block table entry.

d. If the PROCEDURE has the STRING attribute, the length is next analyzed by EXPR.

Output: [PROC sym tab entry] [Expr] [Store length op]

e. Statement label constant LDO is generated but not resolved.

Output: [LDO] [Branch]

f. Statement label constant LDE' defined but not output.

g. Both LDO and LDE' are stored in the block table entry.

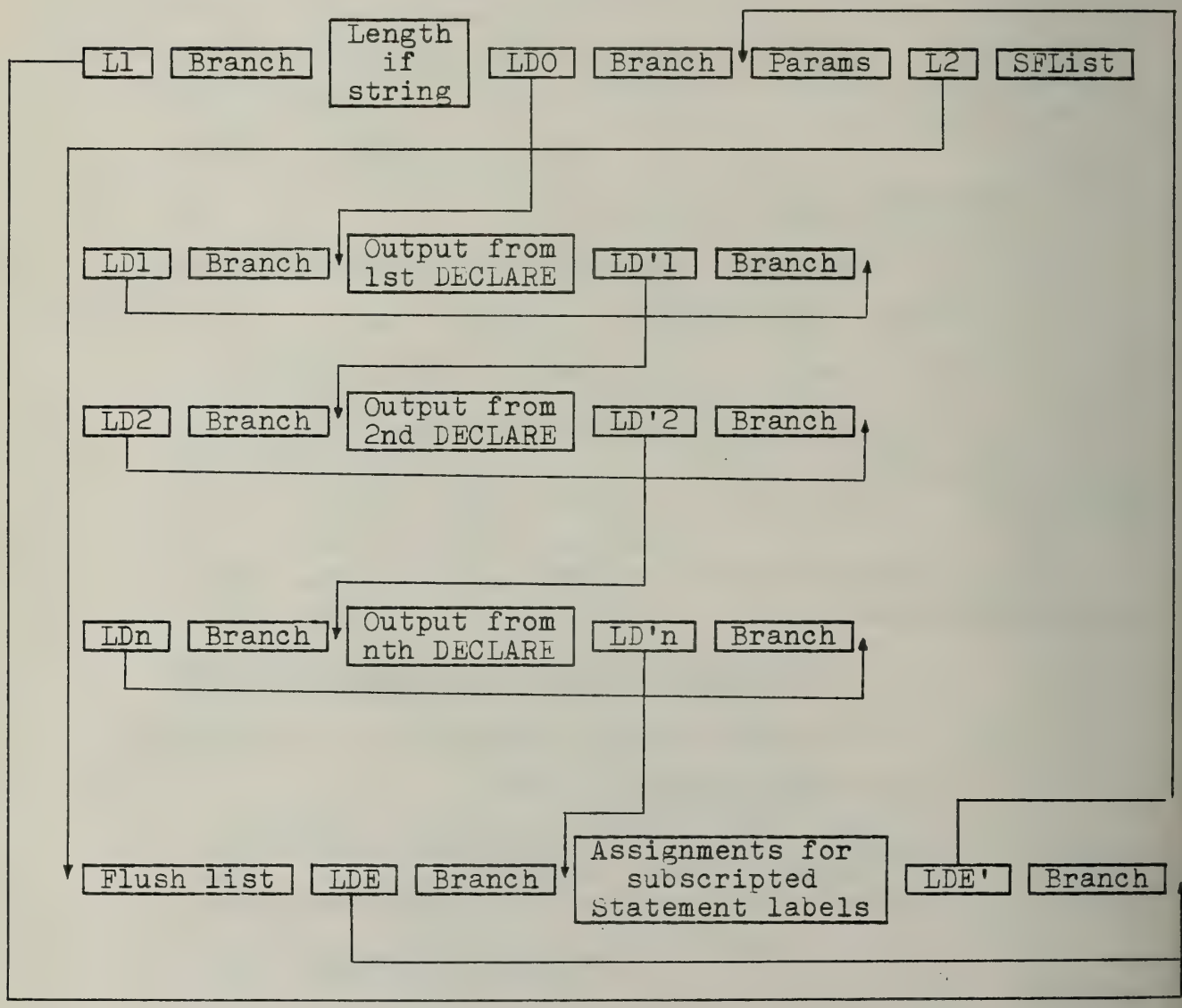
h. Parameters: the parameter list is written out with assignment operators.

i. Statement label constant L2 is generated but not resolved; it is also stored in the block table entry.

Output: | L2 | SFLIST op |

j. The level number is output in LINEOUT for outputting the Flush File.

OUTLINE OF STRUCTURE GENERATED BY
PASS II FOR PROCEDURE BLOCKS
(executable statements are omitted)



The first line is generated by PROCEDURE; the last, by END; those inbetween, by the DECLAREs.

3.3.2.2 BEGIN Statement

a. Labels are treated as in any ordinary statement (not the special treatment of the PROCEDURE statement).

b. A block table entry is constructed for type BEGIN. Any unsubscripted labels are output into this entry.

c. Statement label constant LDO is generated but not resolved.

Output: | LDO | Branch |

d. Statement label constant LDE' is defined but not output.

e. Both LDO and LDE' are stored in the block table entry.

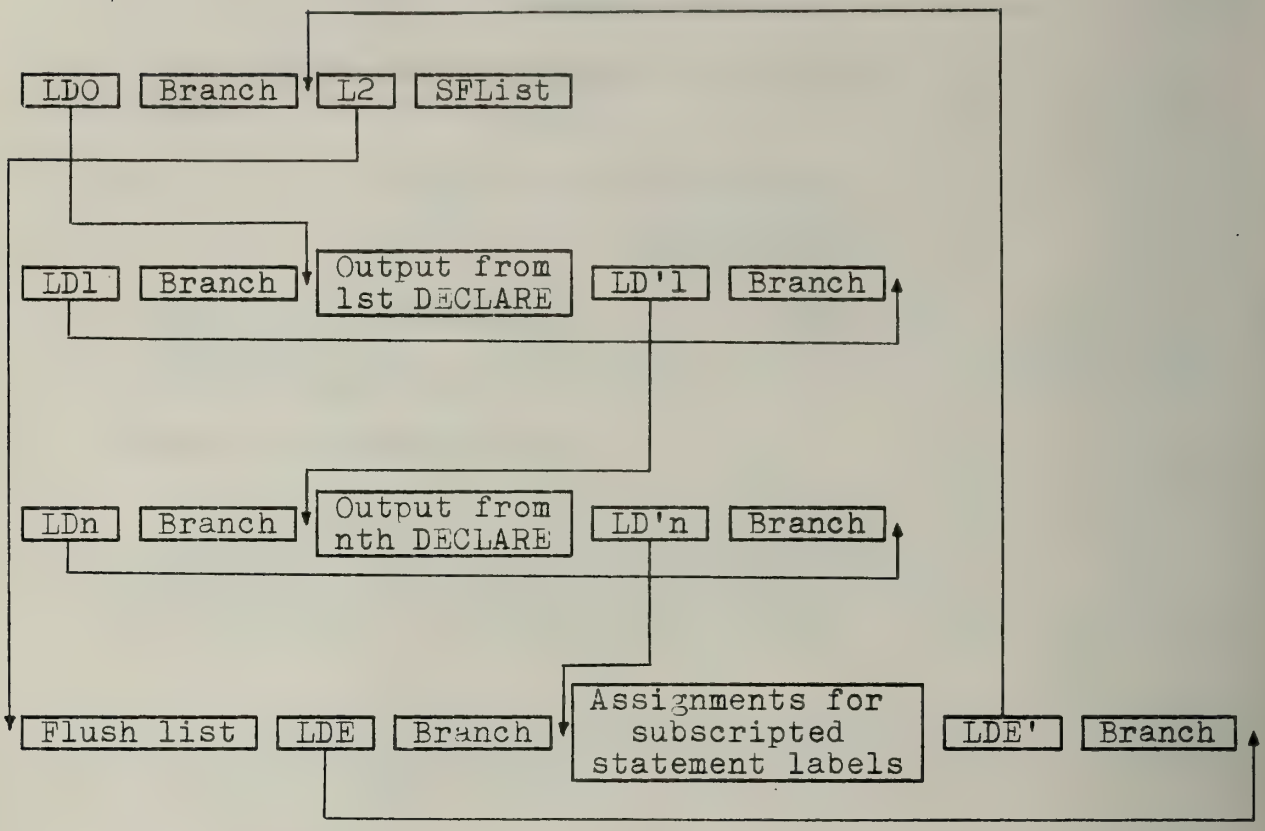
f. Statement label constant L2 is generated but not resolved; it is stored in the block table entry.

Output: | L2 | SFList op |

g. The level number is output in LINEOUT for outputting the Flush File.

OUTLINE OF STRUCTURE
GENERATED BY PASS II
FOR BEGIN BLOCKS

(executable statements are omitted)



The first line is generated by BEGIN; the last, by END; those inbetween, by the DECLAREs. The regular body of code and the DECLARE statements form two separate sections of executable code. Together they form a single flow of program control, as the DECLARE statements end by invoking the main body of code.

3.3.2.3 DECLARE Statement

a. Statement label constant LD_i (i-th DECLARE for the current block) is constructed and stored in core, to be resolved at the end of the DECLARE statement.

Output: [LD_i] [Branch]

b. LDO is retrieved. If it was not previously resolved, this is the first DECLARE for the block, and LDO is now resolved. If it was resolved, LD'_{i-1} is now resolved.

c. The declarations are output, to be executed when the block is entered in Pass III.

d. Each identifier being declared is output into Flush File, to be output when the END statement is encountered.

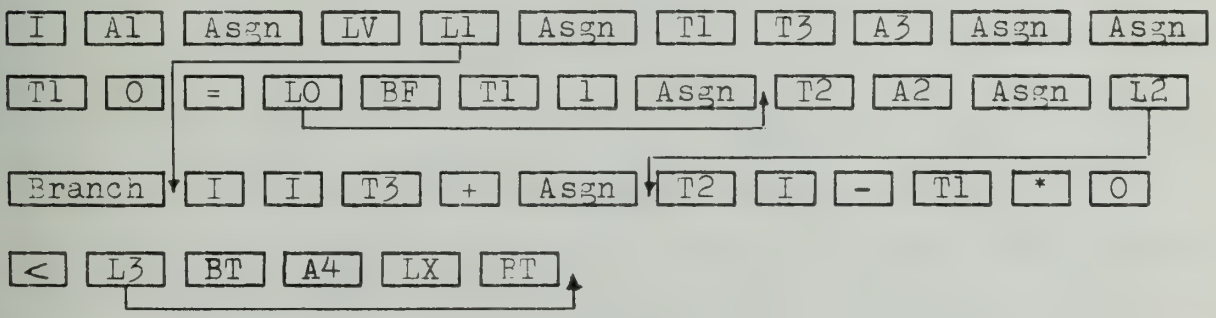
e. LD'_i is generated and stored in the block table.

Output: [LD'_i] [Branch]

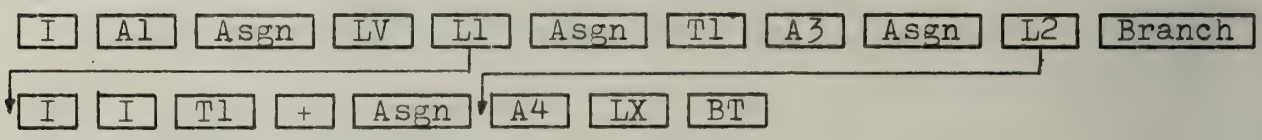
f. LD_i, generated in step (a) is now resolved.

3.3.2.4 DO Statement

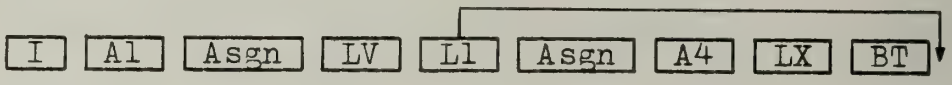
Output for the Type 3 DO statement has been modified to simplify the Pass II DO routine; the output is functionally equivalent to that given in the last report. A specification with all four expressions present (DO I = A1 TO A2 BY A3 WHILE A4) is now output as:



If the "TO" expression A2 is omitted but the "BY" expression A3 is present, the output is:



If both A2 and A3 are omitted (DO I = A1 WHILE A4), the output is:



Finally, in any of these cases, if the "WHILE" expression A4 is omitted,

[LX] [Branch] replaces [A4] [LX] [BT] .

3.3.2.5 END Statement

The END statement may appear either nude or in the form END label; these two are handled (and here discussed) separately.

In the unlabeled case, the current block is closed and its type noted. Further action depends on the type:

a. DO Type 1 -- no further action

b. DO Types 2 and 3

1. Output: [LV] [Branch]

2. LY is now resolved.

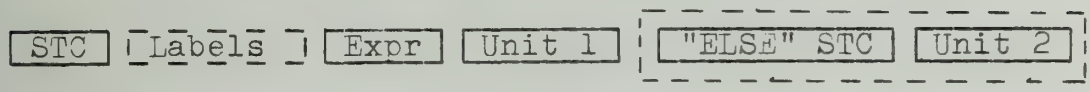
c. BEGIN or PROCEDURE:

1. L2 is resolved, and the Flush List written out. Statement label constant LDE is generated but not resolved.

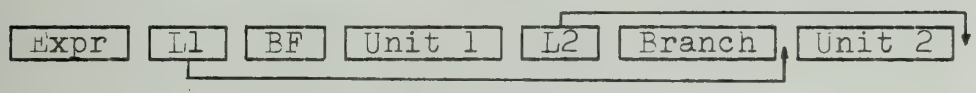
Output: [LDE] [Branch]

3.3.2.6 IF Statement

The input from Pass I for the IF statement is:



Output: If the ELSE is present:



If the ELSE is not present:

Unit 1 and Unit 2 are either statements (except DECLARE, ELSE, END, IF, or PROCEDURE) or BEGIN blocks or DO groups.

Block table entries are made for IF and ELSE pseudo-blocks. L1 and L2 are resolved when these respective blocks are closed.

3.3.3 Preliminary Syntax Specifications

Character Set

PLORTS includes the standard PL/I character set of 29 alphabetics (A through Z, $, @, #) and the digits 0-9. In addition, the following characters are standard on the keyboard and are accepted by the PLORTS system:

blank, denoted herein by the symbol
[(Shift K), translated to ¢
\ (Shift L), translated to ¬
] (Shift M), translated to _
↑ (Shift N), translated to |
! " % $ ' ( ) * + , - . / : ; < = > ?

Arithmetic Operators

+, -, *, /, **(exponentiation)

Logical and Bit String Operators

(¬, not), &(and), ↑(|, or)

Relational Operators

<, \<, <=, =, \=, >=, >, \>

String Operators

↑↑(||, concatenation)

Identifiers

An identifier is a string of not more than 8 characters bounded by delimiters. The first character must be alphabetic; succeeding characters must be alphabetic or numeric.

Statements

Each statement normally is preceded by a line number, and is terminated by a semicolon as in everyday PL/I. PLORTS is restricted to one line per statement and one statement per line. Except as noted, statements may optionally be preceded by labels following the line number.

Statement Types

The following statement types are implemented in PLORTS:

Assignment	GO TO
BEGIN	IF
CALL	Null
CLOSE	OPEN
DECLARE	PROCEDURE
DO	PUT
END	RETURN
EXIT	STOP
GET	

The following are not implemented in PLORTS:

ALLOCATE	ON
DELAY	READ
DELETE	REVERT
DISPLAY	REWRITE
ENTRY	SIGNAL
FORMAT	UNLOCK
FREE	WAIT
LOCATE	WRITE

Restrictions

Structures are not allows. DECIMAL and PRECISION attributes (except SINGLE or DOUBLE for floating point) are not allowed. The DO feature for I/O statements (GET and PUT) is not presently implemented, nor is remote format.

All values are coded internally in binary (no decimal arithmetic is done). Fixed point values are 32-bit integers in two's complement form. Fractional precision is not allowed. Floating point data may be either 32 or 64 bits (24 or 56 bit fraction), to correspond to System/360 single and double precision floating point representation.

Syntax of Statements

The statements in the PLORTS language are defined as in the PL/I Reference Manual except for the diminution of ambiguity and the cases noted.

Assignment Statement

Option 1: {scalar variable / pseudo-variable} [,scalar variable / ,pseudo-variable] ....

= scalar expression;

Option 2: {array name / pseudo-array name} [,array name / ,pseudo-array name] ....

= {array expression / scalar expression};

Option 3: scalar label variable [,scalar label variable] ....

$$= \left\{ \begin{matrix} \text{label constant} \\ \text{scalar label variable} \end{matrix} \right\};$$

scalar variable in Option 1 is either identifier or identifier $(e_1, \ldots, e_n)$, where the identifier is either arithmetic or string; the subscript string is evaluated once from left to right.

scalar expression has the following Backus normal form:

<scalar expression>::=<subexp>|<subexp><log op><se>

<se>::=<scalar expression>

<log op>::=&|↑

<subexp>::=<string>|<subexp>↑↑<string>

<string>::=<term>|<string><rel op><>term>

<rel op>::=<|\<|<= | =|\ =|>=|>| >

<term>::=<addend>|<term><add op><addend>

<add op>::= +|-

<addend>::=<factor>|<addend><mult op><factor>

<mult op>::=*|/

<factor>::=<primary>|<unary op><factor>|<factor>**<primary>

<unary op>::=+|-|\

<primary>::=<constant>|<variable>|<function>|(<se>)

<function>::=<identifier>|<identifier>(<param list>)

<param list>::=<expression>|<param list>,<expression>

<variable>::=<identifier>|<identifier>(<subscripts>)

<subscripts>::=<pair>|<pair>,<pair>|<pair>,<pair>,<pair>

<pair>::=<se>|<se>,<se>

<constant>::=<string constant>|<arith constant>

<string constant>::=<bit constant>|<char constant>

<bit constant>::='<bits>'B

<bits>::=<bit>|<bits><bit>

<bit>::=0|1

<char constant>::='<char string>'|(<unsigned integer>)'<char string>'

<char string>::=<string of characters with no unpaired quotes>
<arith constant>::=<real constant>|<real constant>I
<real constant>::=<decimal constant>|<binary constant>
<decimal constant>::=<decimal number>|<decimal number>E<decimal integer>
<decimal integer>::=<unsigned integer>|<add op><unsigned integer>
<unsigned integer>::=<digit>|<unsigned integer><digit>
<digit>::=0|1|2|3|4|5|6|7|8|9
<decimal number>::=<unsigned integer>|<unsigned integer>.<unsigned integer>|
<unsigned integer>.|<unsigned integer>|
<add op><decimal number>
<binary constant>::=<binary number>B|<binary number>E<decimal integer>B
<binary number>::=<bits>|<bits>.<bits>|<bits>.|.<bits>|<add op><binary number
<identifier>::=
<letter><alpha><alpha><alpha><alpha><alpha><alpha><alpha>
<alpha>::=<empty>|<letter>|<digit>
<letter>::=A|B|C|D|E|F|G|H|I|J|K|L|M|N|O|P|Q|R|S|T|U|V|W|X|Y|Z|$|@|#

Each array appearing in Option 2 must have the same number of subscripts, and the same upper and lower bounds. array expression has the same normal form as scalar expression, except that identifier may be the name of an array.

DECLARE Statement

General format: DECLARE identifier [(b_1,..., b_n)]

attribute [␣attribute]..., identifier [(b_1,..., b_n)]

attribute [␣attribute]..., ...;

All attributes specified for a given identifier must appear immediately after the identifier in the same DECLARE statement. Attributes of external names must not conflict with those declared or default-specified for the same names in different blocks or compilations in which the name is used.

Attributes may be factored in the following manner:

```
DECLARE ((JAMF FIXED, BOAT FLOAT) STATIC,
          NAMGORFN) EXTERNAL;
```

is equivalent to

```
DECLARE JAMF FIXED STATIC EXTERNAL,
        BOAT FLOAT STATIC EXTERNAL,
        NAMGORFN EXTERNAL;
```

The following attributes may be specified by the user:

$(b_1,\ldots, b_n)$	Dimensions
BINARY or DECIMAL	Base for arithmetic variables (see below for use of DECIMAL)
FIXED or FLOAT	Scale for arithmetic variables
REAL or COMPLEX	Mode for arithmetic variables
BIT(e)	Bit string
CHAR(e) or CHARACTER(e)	Character string
LABEL	Label variable
STATIC or AUTOMATIC	Storage class
FILE	
STREAM	
INPUT or OUTPUT or PRINT	Type of file
INTERNAL	Scope of variable

The following attributes are not implemented in the present version:

Precision (except single/double), ABNORMAL, NORMAL, ALIGNED, PACKED, AREA, BACKWARDS, BASED, BUFFERED, UNBUFFERED, BUILTIN, CELL, DECIMAL (except as noted below), DEFINED, DIRECT, SEQUENTIAL, ENTRY, ENVIRONMENT, EVENT, EXCLUSIVE, GENERIC, INITIAL, IRREDUCIBLE, KEYED, LIKE, PICTURE, POINTER, POSITION, RETURNS, SETS, TASK, USES.

Since structures are not implemented, level numbers are ignored.

Arithmetic data attributes: the default scale for BIN FIXED is (15,0); for BIN FLOAT, (21). If the DECIMAL attribute is specified, this attribute is used to determine the scale if none is specified. It is otherwise ignored.

The elements of a label array are initialized by using them as statement labels and may not be initialized in any other way.

e in the string attributes may be either * (for subroutine and function parameters) or scalar-expression with $0 \leq e \leq 255$, and represents the length of the string.

Dimension attribute: this attribute, if present, must be the first attribute following the identifier which is the name of the array. b_i is either * (for parameters) or [lower bound:] upper bound. lower bound and upper bound are scalar expressions. If lower bound is not specified, it is assigned the default value of 1. lower bound must be $\leq$ upper bound. If the array is declared to be STATIC, it must have integer-constant bounds.

DO Statement

The DO statement in PLORTS is handled as it is in standard PL/I, whatever that is. The PL/I Reference Manual distributed by IBM has a number of ambiguities, one of the most serious of which occurs in the discussion of DO. One page of the manual states that such a statement as

```
DO I = 1 WHILE (I = 0)
```

will cause the DO group to be executed once; the next page states that the group will not be executed. In fact, under IBM PL/I F, the group is not executed; PLORTS has adopted this convention.

GET Statement

The syntax of the GET statement as implemented in the present version of PLORTS is as follows:

<GET statement>::=GET␣<get option list>

<get option list>::=<source>␣<get tail>

<source>::=FILE␣(<identifier>)|STRING <identifier>

<get tail>::=<skip-copy><specs>

<skip-copy>::=<empty>|SKIP|COPY|SKIP COPY|COPY SKIP

<specs>::=LIST␣(<get list>)|EDIT(<get list>)(<get format>)

<get list>::=<get element>|<get element>,<get list>

<get element>::=<scalar variable>|<array name>
<pseudo-variable>|<pseudo-array name>

<get format>::=<get item>|<get item>,<get format>

<get item>::=<get spec>|<iteration factor>|<get spec>

<iteration factor>::=<unsigned integer>|(<se>)

<get spec>::=<A spec>|<B spec>|<C spec>|<E spec>|
<F spec>|<X spec>|SKIP

<A spec>::=A(<scalar expression>)

<B spec>::=B(<scalar expression>)

<C spec>::=C(<E of F spec>)|C(<E or F spec>,<E or F spec>)

<E or F spec>::=<E spec>|<F spec>

<E spec>::=E(<se>)|E(<se>,<se>)|E(<se>,<se>,<se>)

<F spec>::=F(<se>)|F(<se>,<se>)|F(<se>,<se>,<se>)

<X spec>::=X(<scalar expression>)

As noted, repetitive specifications are not allowed in the present version.

PUT Statement

The syntax of the PUT statement as implemented in the present version of PLORTS is as follows:

```
<PUT statement>::=PUT␣<put option list>
<put option list>::=<destination><put tail>
<destination>::=<source>
<put tail>::=<s-p-l><pspecs>
<s-p-l>::=<empty>|SKIP|PAGE|LINE|<s-p-l><s-p-l>
<pspecs>::=LIST(<put list>)|EDIT(<put list>)(<put format>)
<put list>::=<put element>|<put element>,<put list>
<put element>::=<get element>|<scalar expression>
<put format>::=<put item>|<put item>,<put format>
<put item>::=<put spec>|<iteration factor><put spec>
<put spec>::=<get spec>|A|B|PAGE|
            COLUMN(<se>)|LINE(<se>)
```

3.3.4 Passing Parameters

It may be noted that the discussion of the Pass II PROCEDURE statement routine (section 3.3.2.1) included a "black box" in the form of [Params]. The workings of this black box are discussed in this section.

The parameters will be found in the stack upon entry to a subroutine procedure. Before the procedure can initialize itself by executing DECLAREs and such, it must protect the parameter by placing a false end-of-stack marker at the top of the stack. Upon return from the declarations and subscripted label initialization, this marker must be popped so as to be able to collect the parameters. Two new operators, ENDSTACK and POPSTACK, will suffice.

Consider now an example:

```
CALL  P(X,(Y),Z+1);
      . . .
P:  PROC(A,B,C);
    A=A+1;
    B=B+1;
    C=C+1;
    END;
```

When the initialization has been performed and control returns to [Params]

the stack will contain:

END OF STACK	X	Y'	Z'	3	PSEUDO END

where Y' is a temporary containing the value Y+1, Z' is a temporary containing the value of Z, and 3 is the number of actual parameters passed.

The first order of business is to pop the pseudo-end-of-stack marker. Then the number of parameters can be checked. For the nonce, let us hypothesize a VERIFY operator whose action is as follows: compare the top two values in the stack, note the result, and pop the two entries. If they were unequal, issue an error message and die. If they were equal, carry on.

Now X, Y', and Z' are left in the stack; these must be somehow connected with A, B, and C. Clearly simple assignment (A = X; B = Y'; C = Z') will not do, since the procedure would not then increment X as desired. Let us define another operator, POINT, as follows: the Polish code | I | J | POINT | will put SYMDUMMY into SYMFORM in J's symbol table entry, and will point J's SYMPOINT to I's symbol table entry (note that I and J are reversed from what the assignment operator might lead one to expect) and will pop both I and J from the stack. This has the effect of indirect addressing (a heresy to 360 people): any reference to J will become a reference to I.

Further, one change will be needed at the beginning of the Pass II PROCEDURE statement routine: it must do a SETSTACK before anythingelse happens, to preserve the actual parameters in the stack.

At this point we can specify the contents of | Params |; we do so here by example. As noted, the stack when | Params | is entered contains

END OF STACK	X	Y'	Z'	3	PSEUDO-END

Now let | Params | contain the following:

POPSTACK	3	VERIFY	C	POINT	B	POINT	A	POINT

where 3 is the number of formal (and hence of expected actual) parameters.

Thus, the effect of [Params] is as follows:

a. Pop the pseudo-end-of-stack marker

b. Verify 3:3

c. [Z'] [C] [POINT] (point C to Z' and make C a dummy despite any declarations to the contrary)

d. [Y'] [B] [POINT]

e. [X] [A] [POINT]

The stack is now empty. Requiescat in pace.

3.4 Display Hardware (R. Hostovsky)

The first stage of the display system is being designed.

This phase constitutes "direct communication" between the PDP8 and the Display Control via the head-per-track disk. In this way, a display can be simulated without the DPU which will be introduced later.

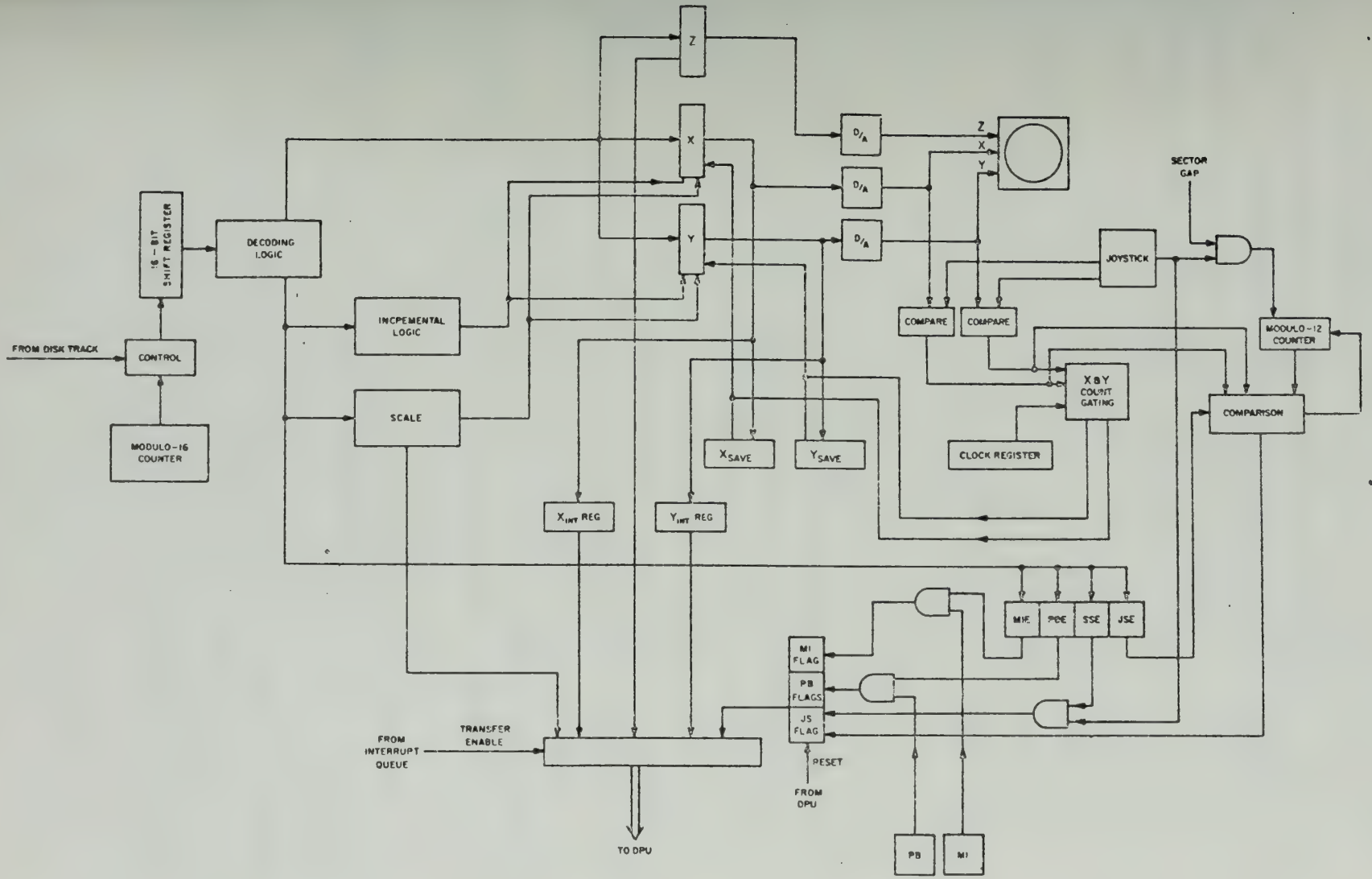
The hardware interface between the PDP8 and the Data Disk was designed last summer and has been modified many times throughout the year.

The Display Control is now being designed. Its functions are:

1. To read a 16 bit word from the disk track, decode it and update the X, Y, scale, and Z (intensity) registers.

2. To display the joystick marker.

3. To control and execute interrupts caused by joystick and push buttons.



Display Control

3.5 Computer Maintenance and Construction (C. Carter, T. Kerkering, H. Lopeman, B. Miller)

The basic PDP8 hardware is usually housed in a single cabinet. When our PDP8-338 was purchased it came with the PDP8 distributed throughout three full-sized cabinets. The reasons for the space expansion were (1) the 16K of core memory and (2) the two dectapes. In the attached figure you can see that the top six racks of cabinet "B" contain the extra 12K of core memory for the basic PDP8. Cabinet "A" is a new one just connected to the original three PDP8 cabinets for integrated circuit logic.

The NJE power supply is a 5V, 20A supply for the new logic. The ampex core memory is the one discussed in Report No. 343. The remaining racks 9, 10, 11, and 12 of cabinet "B" are unused, but will be handy as construction continues.

The data disk (on top of cabinet A) has been re-installed in a small box for purposes of temperature control. The temperature control circuitry is designed and ready for construction and test. The hold-up at present is the delivery of thermostats for temperature sensing.

The two disk interface racks (1 and 2) are being worked on now. A new disk controller is being built using new hardware construction methods allowing for easy changes and expansions as the final graphic system requires.

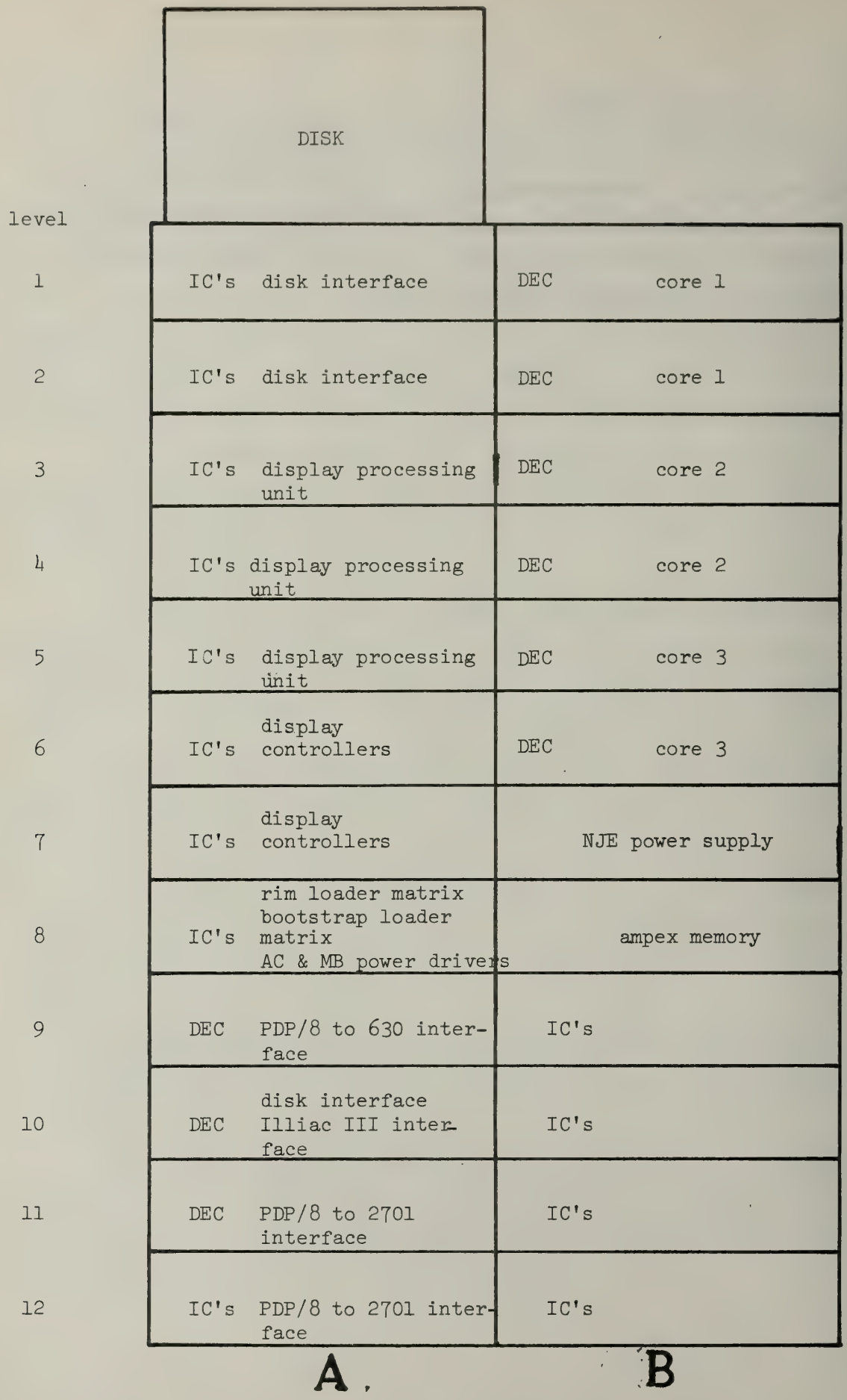
The hardware for the display processing unit and the display controllers discussed in Report No. 343 will be placed as shown in Figure 1 As the designs are completed the hardware will fill in the racks numbered 3, 4, 5, 6, and 7.

Power drives were installed in preparation for heavy fan-out from the accumulator register bits and the memory bus bits. These drivers are located in #8 rack.

The PDP8 to IBM 2701 interface logic is designed, constructed, and ready for test. The hold-up is the delivery of IBM parallel data adapter for an existing IBM 2701 controller. It is hoped that this link will be operational before the first of the year.

3.5.1 Timesharing Hardware

Because of a special requirement the Digital Equipment Corporation interface hardware was changed to accept an IBM 2741 selectric terminal. An exclusive teletype port to the DEC 630 scanner was changed from 10 ch/sec, 11 bit/ch to 14.8 ch/sec, 10 bit/ch. The 2741 is now operating as a direct connect "PLORTS" terminal.


DISK
level
1
IC's disk interface
DEC core 1
2
IC's disk interface
DEC core 1
3
IC's display processing unit
DEC core 2
4
IC's display processing unit
DEC core 2
5
IC's display processing unit
DEC core 3
6
IC's display controllers
DEC core 3
7
IC's display controllers
NJE power supply
8
IC's rim loader matrix bootstrap loader matrix AC & MB power drivers
ampex memory
9
DEC PDP/8 to 630 interface
IC's
10
DEC disk interface Illiac III interface
IC's
11
DEC PDP/8 to 2701 interface
IC's
12
IC's PDP/8 to 2701 interface
IC's
A
B

3.6 Library Subroutines

A quasi-interactive system for locating roots of polynomials, called SPORRT, has been developed. This system is similar in philosophy and construction to SMART[1] which handles the solution of systems of linear equations and eigenvalue-eigenvector computations. SPORRT consists of a PL/1 program to process the command language. This PL/1 program compiles a Fortran program from the command program, and calls a library routine for root finding. A second PL/1 program in SPORRT prints results. When the time-sharing system becomes available this system will be made part of it.

The final report on the SMART routine is being typed. It will be issued as the M.S. thesis of Richard Isler.

A copy of the Traub algorithm for finding roots of polynomials has been obtained and is in the process of being incorporated in the library.

A compilation of test matrices is being made. The material is being prepared in machine readable form. A copy of one test matrix entry is shown in Figure 1. Most of the material here is self-explanatory except perhaps for the condition number. C(1) is based on the matrix norm

$$\|A\|_1 = \max_j \sum_i |a_{ij}| ,$$

C(2) is based on the spectral norm

$$\|A\|_2 = (\text{maximum eigenvalue of } A^*A)^{1/2}$$

and C(E) is based on the Euclidian norm

$$\|A\|_E = \left(\sum_i \sum_j |a_{ij}|^2 \right)^{1/2} .$$

[1] Quarterly Progress Report, October, November, December, 1968.

A complete set of programs is now available for producing a KWIC index on the IBM 360 system. Documentation for these programs is not yet complete. This has been used to prepare a KWIC index for the DCS library. The master file of documents for the DCS library consists of about 13,000 documents. These routines have also been used to prepare a KWIC index for the Children's Research Center; this index contained about 16,000 documents. A limited edition of about 100 copies of the KWIC index for the DCS library is now in preparation. An example of a page of the master index is shown in Figure 2; an example of a page of the author index is shown in Figure 3; an example of a page of the KWIC index is shown in Figure 4.

Harold Becker
Nancy Gray
Richard Isler
Young Jip Kim
Ilona Klein
Richard Taranto
Lloyd D. Fosdick

IDENTIFICATION: 002001

MATRIX: A(I,J)=1 FOR I.NE.J,
        A(I,I)=1 + X
  EXAMPLE (N=5, X=3)

$$A = \begin{pmatrix} 4 & 1 & 1 & 1 & 1 \\ 1 & 4 & 1 & 1 & 1 \\ 1 & 1 & 4 & 1 & 1 \\ 1 & 1 & 1 & 4 & 1 \\ 1 & 1 & 1 & 1 & 4 \end{pmatrix}$$

CHARACTERISTICS: REAL, SYMMETRIC, SINGULAR IF X=0 OR -N.

INVERSE: AINV(I,J)= -1/(X**2 + N * X) FOR I.NE.J,
         AINV(I,I)= 1/X - 1/(X**2 + N * X)
  EXAMPLE (N=5, X=3)

$$AINV = 1/24 * \begin{pmatrix} 7 & -1 & -1 & -1 & -1 \\ -1 & 7 & -1 & -1 & -1 \\ -1 & -1 & 7 & -1 & -1 \\ -1 & -1 & -1 & 7 & -1 \\ -1 & -1 & -1 & -1 & 7 \end{pmatrix}$$

EIGENVALUES: X (N-1 TIMES),
             X + N
  EXAMPLE (N=5, X=3)
    EIVAL(1)= 3
    EIVAL(2)= 3
    EIVAL(3)= 3
    EIVAL(4)= 3
    EIVAL(5)= 8

EIGENVECTORS: FOR THE ISOLATED EIGENVALUE (X + N),
  THE EIGENVECTOR IS
    EIVEC(I,N)= 1 FOR I=1,2,...,N
  AND ANY VECTOR ORTHOGONAL TO THIS ONE IS AN
  EIGENVECTOR WITH EIGENVALUE X.

DETERMINANT: DET(A)= (X+N)*X**(N-1)

CONDITION NUMBERS: ANY CONDITION NUMBER GREATER THAN
  ONE CAN BE OBTAINED BY APPROPRIATE CHOICE OF A
  POSITIVE VALUE FOR X.
  C(2)= 1 + N/X FOR X.GT.0,
  C(1)= 1 + (2*N-2)/X FOR X.GT.0,
  C(E)= SQRT(U*V) FOR X.GT.0
    U= N*(X**2+2*X+N)
    V= N*((X+N)**2-2*X-N)/(X*(X+N))**2.

CONDITION NUMBERS:
  EXAMPLES (X=3)

N	C(1)	C(2)	C(E)
5	3.67	2.67	6.78
20	1.37(1)	7.67	3.85(1)
40	2.70(1)	1.43(1)	9.76(1)
60	4.03(1)	2.10(1)	1.72(2)
80	5.37(1)	2.77(1)	2.58(2)

Figure 1

100	6.70(1)	3.43(1)	3.56(2)

EXAMPLES (X=1)

N	C(1)	C(2)	C(E)
5	9.00	6.00	1.27(1)
20	3.90(1)	2.10(1)	9.35(1)
40	7.90(1)	4.10(1)	2.59(2)
60	1.19(2)	6.10(1)	4.72(2)
80	1.59(2)	8.10(1)	7.24(2)
100	1.99(2)	1.01(2)	1.01(3)

EXAMPLES (X=0.01)

N	C(1)	C(2)	C(E)
5	8.01(2)	5.01(2)	1.00(3)
20	3.80(3)	2.00(3)	8.72(3)
40	7.80(3)	4.00(3)	2.50(4)
60	1.18(4)	6.00(3)	4.61(4)
80	1.58(4)	8.00(3)	7.11(4)
100	1.98(4)	1.00(4)	9.95(4)

REMARKS: ANY CONDITION NUMBER MAY BE ASSIGNED TO THIS MATRIX BY APPROPRIATE CHOICE OF X. HENCE THIS MATRIX IS USEFUL FOR TESTING THE SENSITIVITY OF ALGORITHMS TO ILL-CONDITIONED SYSTEMS. THIS ADVANTAGE WAS POINTED OUT BY NEWMAN AND TODD (REF. 1). THIS MATRIX IS AN EXAMPLE OF A CIRCULANT OR CYCLIC MATRIX. RULES FOR THE DETERMINATION OF THE INVERSE, EIGENVALUES, AND EIGENVECTORS ARE KNOWN FOR THIS CLASS OF MATRICES (REF. 1,2). A BRIEF FLURRY OF PAPERS (REF. 3,4,5,6) APPEARED IN THE CACM BY PEOPLE WHO SEEMED UNAWARE OF THE KNOWN FACTS ABOUT THIS CLASS OF MATRICES. ANOTHER GENERALIZATION OF THIS FORM WAS POINTED OUT BY CLINE (REF. 7).

REFERENCES:

1. MORRIS NEWMAN AND JOHN TODD, THE EVALUATION OF MATRIX INVERSION PROGRAMS, SIAMJ, V6, PP466-476, YR1958.
2. R. ZURMUHL, MATRIZEN, 4TH ED., P231, SPRINGER-VER LAG, YR1964.
3. M. L. PEI, A TEST MATRIX FOR INVERSION PROCEDURES, CACM, V5, P508, YR1962.
4. WILLIAM S. LASOR, TEST MATRIX FOR INVERSION, CACM, V6, P102, YR1963.
5. ROBERT D. RUDMAN, A NOTE ON A SET OF TEST MATRICES FOR INVERSION, CACM, V6, P515, YR1963.
6. A. C. R. NEWBERRY, PEI MATRIX EIGENVECTORS, CACM, V6, P515, YR1963.
7. RANDALL E. CLINE, A CLASS OF MATRICES TO TEST INVERSION PROCEDURES, CACM, V7, PP724-725, YR1964.

Figure 1 (Continued)

```
(1 )DOCUMENT- 0000000001
(3 ) AUTHOR- RUSSELL L. ACKOFF
(4 ) TITLE- PROGRESS IN OPERATIONS RESEARCH
(8 )PUBLISHR- JOHN WILEY AND SONS, INC.
(9 )PUB DATE- //61 (7 )ACQ DATE- //62
(5 ) VOLUME- 1 (10 )NUM PAGE- 505
(17 ) SERIES- PUBLICATIONS IN OPERATIONS RESEARCH
(18 )SERS VOL- 5

(1 )DOCUMENT- 0000000002 (998)OUTR DOC- 0000000001
(3 ) AUTHOR- RUSSELL L. ACKOFF
(4 ) TITLE- THE MEANING, SCOPE, AND METHODS OF OPERATIONS RESE
ARCH
(10 )NUM PAGE- 34

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(3 ) AUTHOR- C. WEST CHURCHMAN
(4 ) TITLE- DECISION AND VALUE THEORY
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(1 )DOCUMENT- 0000000004 (998)OUTR DOC- 0000000001
(3 ) AUTHOR- FRED HANSSMANN
(4 ) TITLE- A SURVEY OF INVENTORY THEORY FROM THE OPERATIONS R
ESEARCH VIEWPOINT
(10 )NUM PAGE- 40

(1 )DOCUMENT- 0000000005 (998)OUTR DOC- 0000000001
(3 ) AUTHOR- E. LEONARD ARNOFF, S. SANKAR SENGUPTA
(4 ) TITLE- MATHEMATICAL PROGRAMMING
(10 )NUM PAGE- 106

(1 )DOCUMENT- 0000000006 (998)OUTR DOC- 0000000001
(3 ) AUTHOR- STUART DREYFUS
(4 ) TITLE- DYNAMIC PROGRAMMING
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(1 )DOCUMENT- 0000000007 (998)OUTR DOC- 0000000001
(3 ) AUTHOR- PHILIP M. MORSE
(4 ) TITLE- DYNAMICS OF OPERATIONAL SYSTEMS.. MARKOV AND QUEUI
NG PROCESSES
(10 )NUM PAGE- 50
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Figure 2

AUTHOR OR EDITOR	DOCUMENT
ALGER, P. L.	0000000006
ALGER, P. L.	0000000030
ALGER, P. L.	0000000054
CHRISTENSEN, N. A.	0000000054
CHRISTENSEN, N. A.	0000000030
CHRISTENSEN, N. A.	0000000006
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DANCE, J. B.	0000000004
DANCE, J. B.	0000000028
DANCE, J. B.	0000000052
DANTZIG, GEORGE B.	0000000058
DANTZIG, GEORGE B.	0000000057
DANTZIG, GEORGE B.	0000000034
DANTZIG, GEORGE B.	0000000033
DANTZIG, GEORGE B.	0000000009
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KOOPMANS, TJALLING C.	0000000011
KOOPMANS, TJALLING C.	0000000008
KOOPMANS, TJALLING C.	0000000032
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KUNEY, JOSEPH H.	0000000041
KUNEY, JOSEPH H.	0000000065
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LIU, C. L.	0000000029

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Figure 4 - KEYWORD-IN-CONTEXT (KWIC) INDEX

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ABACUS EXPLAINED$.....THE JAPANESE  0000006070
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ABERDEEN PROVING GROUND$S OF THE COMPUTING MACHINES AT  0000012248
ABERRATION CORRECTION WITH ELETRON MIRRORS ABSTRACT$..  0000008099
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ABHANDLUNG$LUDWIG WITTGENSTEIN S LOGISH PHILOSOPHISCHE  0000010126
ABHANGIGKEIT VON DER KRISTALLGUTE$RMANIUM IN INDIUM IN  0000000533
ABILITIES FOR ADP OCCUPATIONS$.....  0000010628
ABILITIES FOR ADP OCCUPATIONS$.....  0000010027
ABILITY$ LOGICAL MACHINE FOR MEASURING PROBLEM SOLVING  0000003690
ABLATION PROBLEM USING FINITE FOURIER TRANSFORMS$F THE  0000013211
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ABSORPTION BY LIGHT HOLES IN GERMANIUM$HE FREE CARRIER  0000005813
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ABSORPTION NON DESTRUCTIVE READ OUT TECHNIQUE$RESONANT  0000008562
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ABSORPTION SPECTRA AND ZEEMAN EFFECT OF CHROMIUM ALUMS  0000011725
ABSORPTION STUDIES WITH A HELIUM NEON OPTICAL MASER$OP  0000000469
ABSORPTION TYPE LASER MODULATOR$.....AN  0000000467
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ABSORPTION$.....THE THEORY OF RESONANCE  0000008928
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ABSTRACT AUTOMATION IN DRUG DOCUMENTATION$.....  0000002896
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Form AEC-427
(6/68)
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4. ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III

(Supported in part by Contract AT(11-1)-1018 with the U. S. Atomic Energy Commission and the Advanced Research Projects Agency)

The Illiac III Computer System can be described in terms of 14 constituent subsystems of processors, units and peripheral device groups as follows (see Figure 1):

i) Central System (6 subsystems)

ii) I/O System (3 subsystems)

iii) Peripheral System (4 subsystems)

iv) Power Distribution System (global to all subsystems).

Only one, the Fast Core Storage Modules, is of commercial design. The other constituent subsystems have been designed almost entirely as part of the graduate research program of the Department of Computer Science.

This massive design/development program was not undertaken lightly. Rather, central to the contract program has been the study of the computer architecture appropriate for high speed image processing. These peripheral devices, units and processors must be able to talk to one another -- and with minimum data format conversion: the Scanners feed the Pattern Articulation Unit, whose output in turn is interpreted by a Taxicrinic Unit. This global integration of the design has been costly but integral to the integrity of the system design presented here.

4.1 HARDWARE DEVELOPMENTS

4.1.1 Taxicrinic Processors

Documentation:

Volume I of the TP Manual has been completed and printed. Editing is continuing on Volumes II and III. Volume II of the TP Manual describes the control sequences and control logic for the basic operations common to the TP instruction set as a whole (the so-called "core machine"). Volume III of the TP Manual describes the control sequences and control logic for the individual TP instructions.

At the present time there are about 75 new logic drawings which represent the core machine. These drawings will now be reviewed prior to beginning the card assignment phase in which the individual card assignments and card layouts are specified.

Logical Design:

The first pass logical design for the core machine has been completed. This involves designing each sequence as a unit without regard to interacing problems between sequences. In addition the interfacing between the sequences in the core machine has been finished. However the interfacing between the core machine and the control logic for the TP instruction set will not be completed until after this latter logic has been designed.

Work on the interfacing of the Engineering Console to the TP and other processors and units has also begun. The Engineering Console is a logical device used by maintenance and checkout personnel to maintain and debug the Illiac III processors and units. At the present time it is envisioned to work through the interrupt unit to give various commands to processors and units to enable these devices to be checked out more easily. In particular the console will be able to stop the processors, load and read registers, cause various subcontrol sequences to be executed, etc. The TP-Engineering Console Interface has been specified and the logic necessary for interpreting and executing console commands has been about 50% designed.

B. J. Nordmann

4.1.2 Fast Core Storage Units

All modifications have been made to both FABRI-TEK core memories and checkout is complete. Both memories are now declared to be fully operational and may be attached to the Illiac III System when needed.

S. Paul Krabbe

4.1.3 Arithmetic Units

The bulk of the effort in the last quarter was devoted to the myriad details of sending Volume I of the AU Manual to press. Several sections were revised and augmented. In addition, the wiring tables for the Exponent Arithmetic Unit were rechecked and sent out for wiring.

The following document was recently abstracted in the IEEE Transactions on Computers (Vol. C-18, No. 9, Sept. 1969):

Abstract No. 6975
"Arithmetic Units of ILLIAC III: Simulation and Logical Design," P. L. Koo and D. E. Atkins.

D. E. Atkins

4.1.4 Pattern Articulation Unit

Logical Design: No new work has been done here.

Documentation: No new work has been done here.

Hardware and Wiring: The TM wiring has been completed. Checkout will commence as soon as the power distribution section is checked out. The IA wiring will be continued soon.

Richard T. Borovec

4.1.5 Interrupt Unit

The interrupt unit (IU) of ILLIAC III is a message store-and-forward processing unit through which all processor-processor communication takes place. In addition certain system-wide facilities, e.g. system accounting clock, etc. are maintained by the unit. During the quarter under report, the maintenance console for the ILLIAC III system was defined and IU specifications and functions were redefined to handle the console commands to the processors. The IU logical design and control flow charts are being modified to incorporate the above changes.

Lakshmi Goyal

4.1.6 Exchange Net

The Exchange Net is ready for checkout. Six unit ports and two processor ports will be available for initial checkout. Checkout will begin when DC Power becomes available.

S. Paul Krabbe

4.1.7 I/O Processors

IOP Command Structure

Documentation of the Interrupt Commands and the Device Dependent Commands is almost complete. The description of the IOP program registers and the channel registers is in progress.

The introduction to the Interrupt Command Section describes the basic procedure for executing an I/O process. The rest of this section enumerates the operations performed by the IOP for each of the interrupt commands, and it defines all interrupt command formats in detail.

The introduction to the Device Dependent Command Section puts the concepts of the Device Dependent Commands (DDC's) and their Data Descriptors into perspective and describes the steps the IOP takes while executing a DDC. The body of this section describes the formats of the

DDC's, the formats of the various I/O Descriptors, and the basic operations performed by the seven DDC's.

The section on the registers discusses the relations between the program and the channel registers. In addition it describes the information stored in the various registers and the operations performed on the registers.

Channel Subprocessor

The control flowcharts for the Channel Subprocessor (CSP) have been changed to reduce the amount of intermediate action between the CSP and the channel during channel startup. This means that the Task Subprocessor will receive fewer task requests from a channel just starting, and hence, it will have more time to handle other task requests.

A channel restart capability was added to allow automatic channel restarts for certain channel errors and programmer-controlled restarts for initial device status errors. This feature will reduce the number of I/O programs which will fail due to bad channel or device conditions resulting from an improper termination of a previous program.

Documentation of the channel operations is in progress. The philosophy of the overall channel operation has been described, and the CSP/CIU interface is presently being formalized.

Val G. Tareski

4.1.8 Channel Interface Units

Due to higher priority assignments no material accomplishments have been made on this task.

Joe Wenta

4.1.9 Device Controller

The control flowcharts describing the sequences for connecting with either an Illiac III Channel Interface Unit (CIU) or with an IBM 360 selector or multiplexor channel are complete. The final design of the communications link needed between the Device Controller and any Illiac III I/O device is pending. This can be completed after more experience is obtained with the design of particular Illiac III I/O devices; e.g., the S-M-V Controller.

Val G. Tareski

4.1.10 S-M-V Controller

Considerable progress was made this quarter in the design fabrication and checkout of the S-M-V Controller. In particular all registers and their gates and selectors have been wired and checked out. Three basic portions of the Controller concerned respectively with parameter read in, beam motion, and scanner/monitor communication are now in the final stages of checkout. In particular rasters of all formats prescribed in the SJCC article ("Parametric Description of a Scan-Display System", by L. A. Dunn, L. N. Goyal, B. H. McCormick, and V. G. Tareski, Spring Joint Computer Conference, 1969) are now operational.

Control point design for incremental plotting and display, as well as a few remaining aspects of buffer control associated with coordinate read in/read out are now in progress and should be operational by the end of next quarter.

Bruce H. McCormick

4.1.11 Scan Display Devices

Monitors

Logical design of the monitors consistent with the incremental communication scheme proposed by Tareski was completed. One monitor (Section 2c) was wired and partially tested. The complexity of the incremental control requires that thorough testing await the completion of the remainder of the SMV system. Construction of the remaining monitors can proceed as manpower permits.

Scanners

The analog portions of the scanner have been designed, wired and DC tested. Complete testing of the system (especially signal conditioning) will proceed when the control logic is completed.

Bypass

The bypass (the device allowing communication between the PDP-8 computer and the scanner) has been designed, wired and tested.

Documentation

File Number

805 Franco, Sergio, "Dynamic Focusing and Pincushion Correction Circuit for the Illiac III Display System," August 12, 1969.

810 Franco, Sergio, "A High Speed Analog Divides for the Illiac III Scan System," October 3, 1969.

J. L. Divilbiss

Opto/Mechanical Design

At this time, all of the major mechanical design for all of the scanners and monitors is complete. Some major optical work remains, but substantially all of the mechanical parts are at last complete. It remains to get the machines running and make (we hope) minor improvements.

R. C. Amendola

4.1.12 Intermachine Link

The link to the PDP-8 has been completed and checkout is virtually finished. Complete details of the interface operation will be available soon in a file note.

Richard T. Borovec

4.1.13 Low Speed Terminal Network

No progress was made. This quarter because of the attention to matters of higher priority.

4.1.14 Power Distribution

Processing Hardware:

Wiring - 95%

Control:

Logical Design - 100%
Layout - 95%
Wiring - 70%

Robert G. Thomson

4.1.15 Mainframe Assembly

The following list describes mainframe assembly progress during this quarter:

1. All DC power distribution within the mainframe assembly has been completed.
2. All DC power lines between the mainframe assembly and the DC power distribution wall (Sections 90-95) have been installed.
3. A complete wiring list for all DC power wiring inside the mainframe, and between the mainframe and the DC power distribution wall (Sections 90-95), is available.

S. Paul Krabbe

4.2 SOFTWARE DEVELOPMENTS

4.2.1 Supervisor-Processor Interface Definition

Work on the specification of the instructions necessary for an efficient Supervisory System has continued. The basic Operating System structure has been designed and the problems of dynamic segment linking and the locking out of certain "critical" sections so that only one processor at a time can access to them, have been solved with the use of special hardware instructions. The problem of intertask communication has been solved by the use of two special hardware instructions and proper structural design of the basic Supervisor tables.

B. J. Nordmann

4.2.2 S-M-V Test Program

A set of programs is being debugged which will give a dynamic facility for SMV checkout.

The first, called SCNTST, allows arbitrary control over the parameter bytes for the scanner.

The second, SNOOPY, is primarily for demonstration purposes and allows selection of any window in the scanned image.

Extensive use of subroutines is made allowing other programs to be written without bothering about the nasty details of data management. Details may be found in the file note mentioned in the section on the intermachine link.

Richard T. Borovec

4.2.3 Taxicrinic Processor Simulation

Work has continued on the Simulation of the Taxicrinic Processor. The objective of this project is to simulate the TP hardware logic and control point logic at the signal name level. The simulator has been, and will in the future be, an aid to debugging errors in the design logic.

The simulator has been written entirely in PL/1 for purposes of simplicity. It is hoped that anyone with a small amount of programming experience will be able to follow the logic of the program, and that the code will have a direct correspondence to the actual hardware logic as viewed on design drawings.

About 95% of the simulation of the main registers and functions of the Taxicrinic Processor has been finished, and work has begun on the control sequence logic.

Much experimentation has been done to determine the best way to simulate the control sequences. They are being done on a control point by control point basis. A control procedure has been written which accepts a list of signals, sets them to the "on" state, and causes them to propagate throughout the entire TP. All results of these signal pulses are then printed out (i.e. resulting signals turned on, register contents, etc.).

All the sections are being fully documented so that one can go from a brief understanding of the TP to an understanding of its simulator.

Mary Ann Hagen

4.3 PATTERN RECOGNITION THEORY

4.3.1 Graph Transformation Grammars

The paper "Consistent Properties of Composite Formation Under a Binary Relation," which was mentioned in the last progress report, was issued as Report No. 348 during the past quarter. A second paper entitled: "Graph Transformations for Composite Formation" which attempts to define valid graph transformations on the basis of the properties defined in the previous paper was also completed.

This theoretical work developed out of the study of the relative precedence of graph transformations for image processing when an abstract graph model of simple drawings was used.

Currently we are summarizing these past ideas to clarify the relationship of the theory to the original problem domain of image processing. We are also investigating other areas where a composite analysis approach may be applicable.

4.3.2 Game Model of Image Processing

No further investigation of sequential recognition procedures using the game model of selective information starvation was carried out during the past quarter.

4.3.3 Analysis of Simple Line Drawings

The heuristic approach used by Guzman[1] to cluster regions in a scene which are parts of the same three dimensional solid was studied. This approach depends on vertex type classification to establish links between regions and then merge regions.

We have reformulated these heuristics in a digraph model which maintains named relations between regions. This approach seems to have a number of advantages for a more general name-independent parsing technique and later model directed recognition. In particular it appears that by maintaining named relations at the abstract graph level, a larger

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[1] Guzman, A., Computer Recognition of Three-Dimensional Objects in a Visual Scene, MAC-TR-59 (Thesis), Project MAC, M.I.T., Dec. 1968.

class of heuristics which can be uniformly specified by graph transformations are available.

This area is being studied further as one application of a general composite formation model.

John C. Schwebel

4.4 DOCUMENTATION

4.4.1 Circuit Books

Six new circuits or variations of circuits have been documented and released for distribution to Circuit Books.

Two circuit changes have been processed and released for distribution.

Four additional new circuit variants are in process of documentation at this time.

John C. Schwebel

4.4.2 Logic Books

No new enters into Logic Books have been made during past quarter.

Set of Power Turn-on logic drawings has been 50% completed.

S. Zundo

4.4.3 Opto/Mech. Design

From July 1 to September 30, 1969, fourteen (14) new detail, assembly, and layout drawings were made.

Two (2) additional drawings were processed for engineering changes.

Two (2) work orders were placed with D.C.S. Machine Shop, two (2) with Physics Machine Shop, and two (2) placed with E.E.'s Electro-Chemical Laboratory.

R. C. Amendola

Reports and File Numbers Issued

Report Number

Report No. 342	Part I: Technical Progress Report
Report No. 348	Schwebel, J. C., McCormick, B. H., "Consistent Properties of Composite Formation Under A Binary Relation", August 12, 1969.

File Number

File No. 805	Franco, Sergio, "Dynamic Focusing and Pincushion Correction Circuit for the Illiac III Display System", August 12, 1969.
File No. 810	Franco, Sergio, "A High Speed Analog Divider for the Illiac III Scan System", October 3, 1969.

Senior Staff

Dr. James L. Divilbiss - Principal Research Engineer
Professor Bruce H. McCormick - Principal Investigator
Professor Sylvian R. Ray
Professor K. C. Smith - Consultant

Professional Staff

Robert C. Amendola
Richard T. Borovec
Mrs. Linda M. Katoh
Ronald G. Martin

Electronic Engineering Assistants

S. Paul Krabbe
Frank P. Serio
Joseph V. Wenta

Electronic Technician II

John L. Fileccia
Robert G. Thomson

Electronic Technician I

George T. Lewis
Bennie D. Williamson

Engineers

*Daniel E. Atkins
*Jayaramamurthy
*Lakshmi N. Goyal
*Richard P. Harms
*Bernard J. Nordmann
*Christian Rey
*Val G. Tareski

Programmers

*John C. Schwebel

Drafting

Stanislavs Zundo

Secretarial

Mrs. Mariam Coleman

*Research Assistants

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5. ILLIAC IV

(This work was supported in part by the Department of Computer Science, University of Illinois, Urbana, Illinois, and in part by the Advanced Research Projects Agency as administered by the Rome Air Development Center, under Contract No. USAF 30(602)-4144.)

REPORT SUMMARY

At the conclusion of this quarter the following milestones were agreed upon by the University of Illinois and the Burroughs Corporation:

Event	Date
Debugged Prototype PE	Oct. '69
Debugged Production PE	Feb. '70
CU Ready for Integration, Start System Integration	Feb. '70
System Confidence Demonstration	Apr. '70
Ship One-Quadrant System	Aug. '70
Final Acceptance Test at University of Illinois	Nov. '70

The semi-conductor memories to be produced by Fairchild are two weeks to one month behind schedule. The memory chips for the prototype processing element memory appear to be sound and operable, however, Fairchild is experiencing yield problems. Fairchild is currently developing a new set of procedures and equipment to test memory chips at the wafer level.

Texas Instruments is currently meeting Burroughs' delivery schedule in providing the dual-in-line packaged ECL circuits for ILLIAC IV.

The PDP-9 computer, which will be attached to the PE exerciser to provide the ability to automatically diagnose errors in the PE and

CU boards, was delivered to the University in August. Components for the interface to the PE exerciser have arrived at the University and the interface is currently under construction. Software development for the PDP-9 is proceeding on schedule.

A new version of the "ILLIAC IV Systems Characteristics and Programming Manual" has been delivered by Burroughs to the University and distributed to the appropriate personnel. The University and Burroughs are working together to gather comments, criticisms and corrections to be incorporated into the next update of the manual to be published in January, 1970.

FOURUM, the ILLIAC IV user's group, continues to grow and the present membership is at 140. The distribution for other research documents is in the process of being automated and all mailing lists are being centralized into one file.

Burroughs has agreed to accept an incremental conversion of the present contract to a fixed price contract. Target dates for specific tasks which are to be converted to fixed price are currently under negotiation.

The project initiated last quarter to permit Burroughs' ALGOL to be compiled and executed on a Control Data Corporation 6000 series machine has been partially completed. A preprocessing program that translates Burroughs ALGOL and XALGOL into CDC ALGOL is currently operational. A more comprehensive program should be available next quarter.

The building plans for the Center for Advanced Computation were approved by the President of the University of Illinois and the Board of Trustees. Bids for general construction have been let.

5.1 Logic Simulation and Diagnostics

5.1.1 Logic Simulation

5.1.1.1 PE Simulator

The CU Card Simulator Generator System has been extended and applied to the generation of PE Card Simulators. The net lists (wire lists) of 35 PE card types were compiled from Burroughs' logic diagrams. Error messages from the programs of the Generator System helped in removing some errors in translation and in card punching of the net list as well as in the logic diagrams. The connector pin assignment in the diagrams was compared with Burroughs' assignment list which was being used in the generation of the backplane wire list. All of the PE card net lists have been released for simulation and test generation.

5.1.1.2 CU Simulator System

The CU Card Simulator Generator System is now complete, with the facilities for automatic sequential execution and history generation.

Some experiments of CU Card Simulation were made and the system was verified.

The system will be used for debugging the logic of CU cards and for generating Bad Card Simulators.

The design of the CU Section Simulator Generator System was resumed in September. The System will be implemented in the next quarter and used for checking the design of the Control Unit.

5.1.2 Card Test Generation

5.1.2.1 Card Test Generator

In this period, a final version of the Card Test Generation System has been completed and debugged.

To allow more flexibility and to meet additional requirements (e.g., initialization of the latches present in some boards and holding some signal values at a constant during the simulation instead of varying them in a random manner), a new program has been incorporated into the system.

It is expected that the capabilities of the system will be extended in the near future to facilitate failure isolation in addition to failure detection.

5.1.2.2 Card Test Translation

The two main functions of the Card Test Translator are: (1) to print out the test patterns and the list of failures associated with patterns in an adequate form, and (2) to translate the patterns and failure information into PEXTAP (PE Exerciser Test Assembler) language.

The first function has been completed and the second function is being debugged. The program will be completed in the next quarter with some extension of the functions.

5.1.2.3 Generation and Evaluation of Card Tests

More than half of the 35 PE cards have been simulated for test generation. In most cases, a set of patterns which can detect all failures in the DIL packages on the card, was obtained in a short running time (between 10 seconds and 2 minutes) on the B5500. The rest of the time required on the computer was about 10 minutes including simulator compilation and random pattern generation.

Also, a few CU cards were simulated for test generation during this period. All failures were detected on one of the cards. The input partitioning and the initialization of the storage states seem to be very important for efficient test generation.

Burroughs has compiled a list of possible failure modes in DIL's by analysis of the circuits. Work is continuing at the University to correlate their results to the failure modes assumed in the Card Test

Generator. It appears that practically all failure modes defined by Burroughs can be covered as single or double failures in the Card Test Generator.

5.1.3 PE Diagnostics

The path test generator system was used to generate a revised test program for the new prototype PE. Combinational tests have not yet been revised for the new design.

One of the last programs of the Control Logic Test Generator System is being coded. This program will detect and solve conflicts in the assignment of values to input signals.

5.1.4 PEX Computer and Supervisor System

Delivery of a Digital Equipment Corporation PDP-9/L computer to be used as a PEX controller was made at the end of August. Characteristics of this system are:

1.5 μsec cycle time
18 bit word length
16K words of core storage
Hardware multiply and divide
3 DECtape transports
1 IBM compatible magnetic tape transport

Coding and assembly of the previously defined PEX supervisor is progressing satisfactorily. Early hands-on experience with the computer was gained through coding and assembling of several utility routines to speed development of the PEX supervisor. Typical of these is a magnetic tape handler which permits listings to be written on a magnetic tape whose contents are then printed using the high speed line printer of the Burroughs B5500.

The interface to the PEX will be made by modifying the second paper tape reader channel on the PEX, and then constructing an interface to the PDP-9 which will accept data words from the PDP-9's data channel

and serialize them into characters. Design of the interface was accomplished during August. A misunderstanding between Burroughs' and the University's logic designers about the exact details of the interface required that small modifications be made in mid-September.

Actual construction of the interface has been delayed awaiting arrival of the necessary components. It is expected that the interface construction will be completed at approximately the same time as the programming, and that the entire system will be delivered to Burroughs in time to check out the first production PE's.

5.2 Design Automation

5.2.1 Post Processor Program

The Post Processor (Printed Circuit Wiring Analysis) Program is being used for production of the CU printed circuit boards. The program's output has been useful as an additional tool for updating and completing the PC Artwork. The need for substantial manpower to manually check the automatically produced artwork has been eliminated.

5.2.2 CU Printed Circuit Layout

The University and Burroughs have completed arrangements for doing the DA for the CU PC layout. Approximately 12 hours of processing is done on the University's B5500 system per PC board. The University's system can provide better turnaround and throughput for this larger amount of processing and save additional billing to the project. It is planned to complete this effort during the next quarter.

5.3 Operating System

Several modifications were made to the operating system to provide for the first pass October system. A second job parser was designed and is being debugged. This job parser is a simpler module than the first and should be more reliable during early debugging of the first system. The loader functions have been subsumed by the program collector and execution monitor. Since multiple relocation and overlay loading would not be required in the first system, the program collector was modified to produce a relocated program segment suitable for direct loading into the ILLIAC IV memory. Thus, the loader was made unnecessary and the read operation needed to place the program in the array was assigned to the execution monitor.

The hardware supervisor intrinsics were frozen and the implementation of buffer files on the B6500 has begun. Contrary to expectations, Burroughs will not include the buffer file facility in its first Master Control Program (MCP).

The execution monitor, data processor, and job partner depend heavily on the MCP. Due to the moving target nature of the MCP, the specification of critical sections of each of these modules was not made until mid-September. It was decided to freeze the design on the basis of current knowledge of the MCP and to modify the delivered MCP to represent the situation on which the design was frozen. It is expected that this may entail an extensive amount of debugging time when the B6500 is first delivered.

Parts of the system have been coded in SIMULA so that their activity can be simulated and debugged before the arrival of the B6500. Currently, simulation activity in concerned with disk allocation and quadrant execution.

5.4 Translator Writing System

Most of the steps of the system described last time have been implemented and effectively debugged. BNF2FPL/TWS, FPL2PAR/TWS, PAR2ALG/TWS, and the parser files are all functional. TWINKLE/DISK is working, except for a few of the TWINKLE constructs; work on ISL/DISK is just beginning. Use of the new system has already begun. From the results obtained so far, the expectations for the new system have been met. The interpretive parser is very similar in all respects to the previous one, but the executable parser is significantly smaller. The executable parser is small enough (13K core estimate for executable TESLA compiler compared with 10K for the interpretive version and 18K or 20K for the old executable version) that it has become a very desirable choice for small to medium-sized languages. A further advantage is that three different pieces, the filling of the parsing tables, the lookahead procedure, and the Floyd production procedure calls, can be made executable or interpretive independently.

5.5 Compilers and Translators

5.5.1 TRANQUIL

Progress on the TRANQUIL compiler was slowed during this quarter due to personnel changes and vacations. Brisk activity on the compiler was resumed during the last two weeks of the quarter. While coding and debugging of the TRANQUIL basic subset due for completion in October continues, development and design effort has been centered on implementation of explicit I/O statements for the language.

The implementation of procedures in TRANQUIL has been completed on time. Some slippages are apparent in the coding and debugging of the basic subset. It was hoped to have coding completed by the end of October, but November is now the target date. Debugging will take longer and will be a function, in part, of the user's perseverance in utilizing what is available.

5.5.2 GLYPNIR

Work on GLYPNIR proceeded slowly during this quarter because of a reduction in staff. Even so, several additions and extensions to the compiler were made. The compiler now accepts numeric literals, including floating point numbers with exponents and base designators. Also, partial word operators (similar to those of BURROUGHS EXTENDED ALGOL), the AS construct (which allows the programmer to make a GLYPNIR register synonymous with an ILLIAC IV hardware register), and several new control card options have been added which will make debugging easier.

Work is also progressing on the debugging of system subroutines such as sine, cosine, tangent, natural log, and square root. These system subroutines will be introduced during the early part of the next quarter.

5.6 Assembler

July and August were spent in fixing the final design for the macro assembler. Implementation of the macro assembler, according to this design, began in September.

5.7 Utilities

The utilities effort commenced during this quarter. The initial effort is concentrated on developing two formatted data processing programs. One will take data from external sources and put it on the B6500 disk in the form required by the operating system for transmission to the ILLIAC IV disk. The other program performs the inverse transformation: it takes a file which was transmitted to the B6500 disk from the ILLIAC IV disk and formats the data for external representation.

Other areas under consideration are:

(a) debugging facilities

(b) graphic display software

(c) software to permit user measurement of program performance with an eye to hardware usage and time optimization.

5.8 B5500 Operation

The present status of the MCP is Mark IX, LEVEL 51.14. In July 175.16 hours, in August 174.70 hours and in September 202.39 hours of processor time was logged.

5.9 Numerical Analysis

5.9.1 Monte Carlo Transport

A two-dimensional Monte Carlo Transport program is currently being written in GLYPNIR. Straight storage is used for the variable storage scheme. The program will accommodate approximately 64 x 64 spacial cells, and only 180 x 64 particles, but appropriate buffers are being provided so that particles can be streamed in and out from the disc. The coding is more than 50 percent complete.

5.9.2 Mathematical Subroutines

The following subroutines have been completed and simulated.

Function	Precision in Octal Digits
sine	15 ~ 16
cosine	15 ~ 16
tangent	15 ~ 16
cotangent	15 ~ 16
arccosine	15 ~ 16
arcsine	15 ~ 16
arctangent	15 ~ 16
natural logarithm	14 ~ 16
exponential	14 ~ 16
square root	15 ~ 16

The subroutines are entered with 64 arguments and they return 64 answers. Computer Approximations, by Hart [1], was the source for the approximating functions. Accuracy was determined by comparing results from the ILLIAC IV simulator with double precision results from the 360/75. Corresponding routines for 32 bit operands will be provided as they are needed.

5.9.3 Automatic Solution of Initial Value Problems

An investigation was initiated this quarter to determine the feasibility of constructing a general purpose program to solve initial value problems of the form:

$$\frac{\partial \vec{u}}{\partial t} = \vec{A}(\vec{u}) \tag{1}$$

where A may be a non-linear operator involving partial derivatives with respect to spacial variables. Especially encouraging in this investigation is the success the University has had with automatic integration programs to solve large sets of ordinary differential equations of the form:

$$\frac{d\vec{z}}{dt} = \vec{f}(\vec{z}) \tag{2}$$

It can be shown for certain operators A (for example $\partial^2/\partial x^2$) that many of the successful finite difference schemes for solving (1) may be derived by first discretizing the spacial variable, forming a large set of ordinary differential equations, and then solving the ordinary differential equations using a conventional scheme. Considering accuracy and stability there is no difference in the approach. This suggests that we may capitalize on the success of the automatic integration of ordinary differential equations in the integration of partial differential equations.

The two pressing questions which must be investigated are: (a) Can the spacial mesh be refined independently if the algorithm for solving the ordinary differential equations has certain properties? and (b) Will it be possible to first approximate A by another operator A* which will insure that discontinuities in the solution (i.e. shocks) will not completely destroy the numerical solution? If these questions can be answered affirmatively, it may then be practical to develop an automatic solution program.

5.9.4 Eigenvalue Problems

The program, for Jacobi's method for eigenvalues of symmetric matrices with a "Triangular Skew" storage scheme, has been written and is now in the process of being simulated and debugged.

The problem most apparent at the present time is finding a suitable method of keeping track of the elements in a most efficient way. Since in each transformation of the matrix only those row-elements change their locations whose index $n \leq \#$ of transformations, the method described in QPR Document #219 [2] seems inefficient, since it calculates all locations of all elements.

The method being developed sees the location of the elements of one row as a function of the locations of the elements of the previous row with the adjustment that each row has one element less than the previous one. This method also involves a minimum of element-manipulation.

5.10 Linear Programming

Major projects for the Linear Programming (LP) group this quarter have been the SSK simulation of LPS (small linear programming system) and an investigation of the gradient projection method as a technique for LPL (large linear programming system).

One of the significant benefits that linear programming by the simplex method will receive from ILLIAC IV is in the realm of "multiple pricing". Behind this concept lies the fact that no computer-implemented LP system can afford to examine the entirety of a large constraint matrix (A-matrix) each iteration. Typically, reduced prices (d_j's) are computed for only one portion of the A-matrix columns (partial pricing). A smaller number (about 5), with the most favorable prices, are selected for pivot evaluations. This is multiple pricing. Updating such a set of vectors is time-consuming, so suboptimization is performed with this set; that is, as many of these vectors as possible are introduced into the basis before reconsidering the remaining A-matrix columns.

The massive "crunching" capability of the ILLIAC IV allows the entire A-matrix to be scanned in determining the pricing vectors. A major iteration consists of pricing all columns of the A-matrix and selecting and transforming those selected for multiple pricing. LPS handles up to 127 (vs. 1-10 on a conventional machine) of these vectors for suboptimization. The suboptimization steps are called minor iterations. The pivot element is determined for each of these transformed vectors; the one producing the greatest improvement in the objective function is selected for pivoting. When the remaining transformed vectors produce insufficient objective function improvement, a new major iteration is initiated.

The pricing and candidate selection portion of the major iteration (DSCHUZ) has been successfully simulated this quarter. Consisting of three sequentially executed steps, DSCHUZ (1) calculates the d_j's for the entire A-matrix and selects an optimum subset--usually 512--of these, (2) refines this set to $N \leq 127$ vestors and (3) executes an inter-PE sort on the selected values. The result is a column-sorted array containing tags and cost values for the selected vectors. Then the N most probable vectors to enter the basis can be column-sequentially processed in minor iterations. Simulation tests of other LPS routines will be carried out as machine time becomes available.

Investigation of gradient projection as a solution technique for LPL (large linear programming system) has produced a preliminary recursion algorithm for the method. It takes a form which is similar in concept and importance to the recursion introduced by the product form inverse in place of the explicit inverse of the revised simplex method. Studies of the vector densities produced and the resulting storage requirements are somewhat alarming at present; modifications are being considered as the investigation continues.

5.11 Long Codes

During this quarter, the identification of a stationary dynamical system with plant and observation noises was attempted. A

least-squares estimation yielded an estimation error that remains bounded, but it did not provide an upper bound on the size of this error in the limit.

A stochastic approximation algorithm was constructed based on some theorems by Dvoretzky [3] and by Venter [4]. It was shown that the proposed algorithm yields an estimation error that approaches zero in the mean-square sense.

5.12 Radar Data Processing

During this period, work was completed on the documentation of the ILLIAC IV Kalman Filter. A complete write-up has been printed and is available as ILLIAC IV Document #222, entitled "A Kalman-Filter Tracking Program for ILLIAC IV" [5].

A complete subroutine package for doing Fourier transforms is being written for ILLIAC IV. It uses the Cooley-Tukey algorithm and can handle data sets which can vary from 8 to 4096. The algorithm is programmed in a 32-bit floating point mode for complex numbers, where the real and imaginary value of each reside in one 64-bit PE. This program is expected to be running by the next quarter and complete documentation will be started.

5.13 Seismic Signal Processing

Several programs, previously written, were modified to make them more flexible. One research assistant, working on these programs, was beginning to convert these B5500 ALGOL programs to ILLIAC IV assembly language until the draft board assigned him to a different area of responsibility.

Research into multi-channel filter design has continued during this quarter.

Since the data received in seismic recording is all real, rather than complex, a modification of the Fast Fourier Transform

program to accept two streams of real data has started. This program has been postponed until the fourth quarter when additional personnel will be acquired.

5.14 Conversion of Burroughs ALGOL to CDC 6000 Series ALGOL

A preprocessing program that translates Burroughs ALGOL and XALGOL into CDC ALGOL is operational. Both, the ILLIAC IV assembler and simulator, have been properly processed by this program.

Certain Burroughs constructs, such as SCAN and REPLACE statements, are changed into function calls. All references to input-output are also changed into function calls. The necessary subroutines must be written for the CDC machine. It is expected that work should be completely finished by the end of November 1969.

Programs will run 20 percent faster on the CDC machine than previously estimated.

5.15 ILLIAC IV Education and Documentation

5.15.1 CS 491-D

The graduate course in Computer Science "Architecture, Applications and Languages for a Parallel Computer" is being offered again this fall. The course outline is as follows:

I. Machine Design . . . (Walt Heimerdinger) . . . . 6 classes

Conventional Machines.....1
Unconventional Machines....5
Holland/SOLOMON...1
ILLIAC IV.....3
ILLIAC IV/B6500...1

A short history of conventional machine design will preface a discussion of the antecedents of ILLIAC IV, namely the Holland and SOLOMON machines. The discussion of the ILLIAC IV organization will include discussion of the architecture of the B6500.

II. Operating System and I/O . . (Marv Graham) . . . 2 classes
(Tom Mason)

The operating system is presented as the "glue" binding the B6500 and the ILLIAC IV. The I/O subsystem will be explored for timing and operational relationships.

III (a). Introduction and General
Overview of Software . . (Prof. Northcote) . . 1 class

III (b). Software . . . . . 11 classes

Assembler/Simulator . . (Dave Grothe) . . 3
(Gary Grossman)
GLYPNIR . . . . . (Duncan Lawrie) . . 4
TRANQUIL . . . . . (Norma Abel) . . 4

The major languages of the ILLIAC IV are presented. An effort will be made to highlight the useful aspects.

IV. Communicating with the User . . (Pete Alsberg) . . 1 class

A discussion of data storage devices and data displays.

V. Applications . . . . . 8 classes

Numeric . . . . . (Dave McIntyre). . . . 4
Radar . . . . . (Morris Knapp). . . . 2
Linear Programming . . (Serena Yardley). . . . 2

The major uses of these applications will be sketched in terms of how ILLIAC IV is essential to these areas. Techniques dependent on unique characteristics of ILLIAC IV will be emphasized.

5.15.2 Training Programs

As the delivery of ILLIAC IV draws closer, it will be necessary to initiate training programs to educate people in the use of ILLIAC IV. Various types of programs are currently under consideration to service three types of people.

(a) Personnel working directly for the ILLIAC IV Project at the University of Illinois (U of I)

(b) Personnel at the U of I who do not work directly for the ILLIAC IV Project

(c) Personnel outside the U of I who do not work directly for the ILLIAC IV Project but are interested in becoming users of ILLIAC IV.

5.15.3 Documentation

Due to the growing list of people, both internal and external to the U of I, who utilize ILLIAC IV Reports and Documents and the User's Group--FOURUM, a master file has been established. This master file will effectively automate and simplify mailing procedures and will centralize user descriptive data into one source.

The Library of ILLIAC IV documents is currently undergoing re-organization to allow for future expansion and to make it easier to use. ACM (Association for Computing Machinery) category codes will be coded to existing and future documents.

5.15.4 ILLIAC IV Textbook

Work has started this quarter on "The ILLIAC IV Computer--A Programmer's Text".

The book is an attempt to present, under one cover, the information necessary to instruct a programmer in the use of ILLIAC IV. To this end, the book has been partitioned into two distinct sections. The first section, the chapters, are in conventional textbook format including problems to be solved by the student and topics for discussion. To facilitate the learning process, the information presented in the chapters is quite general in nature--only those concepts necessary to give the reader a basic understanding of ILLIAC IV are presented.

The second section, the appendices, refine the information presented in the chapters. The appendices act as a reference manual, or a handbook. Either section of the book can be read independently of the other.

Chapter I is a review--a selected history of computing machines. The evolution of digital computers is described in terms of the problems that had to be solved. The growing, changing capabilities of computers are discussed, leading finally to ILLIAC IV.

Chapter II is a broad outline of the ILLIAC IV hardware structure. A sample problem (LaPlace's equation for temperature

distribution in two dimensions) is used to illustrate how the components of the hardware structure are tied together.

Chapter III describes the major programming languages available to the ILLIAC IV user. The sample problem of Chapter II is re-visited to explore the use of the assembly language ASK and two high level languages, GLYPNIR and TRANQUIL.

Chapter IV presents the system software that is available to the user. The I/O system including the B6500 computer, ILLIAC IV disk, DFC, BIOM, IOS, CDC and TMU is described. The operating system is covered in a skeletal fashion and a typical job is traced as it flows through the system. Software capabilities of specific hardware components such as remote terminals, graphics, IMP and the ARPA network, and various other peripheral equipments are also covered.

Chapter V discusses applications of ILLIAC IV and indicates the types of problems that are especially amenable to solution on such a parallel processor.

5.16 Graphics

The following specifications are currently being proposed as the graphic requirements for ILLIAC IV:

I. CRT Requirements

- A. 2048 X 2048 resolution with character and vector capabilities.
- B. Input channel of $\gtrsim 10^5$ bits/sec. (see II.B.)
- C. Need at least one CRT of TV size for viewing, with keyboard for limited interaction. "Light pen" interaction and intermediate hard copy with fair quality and limited quantity (~15 sec/page) are highly desirable if not too costly.

II. Photographic System

- A. 16 mm and 35 mm microfilm cameras with sufficient registration for movies.
- B. Required rate for microfilm estimated at 1 frame/sec with an estimated 5000 instruc/frame or 5000 characters/frame (this

requires CRT input channel of $\gtrsim 10^5$ bits/sec). Development time of less than 30 minutes desired.

C. Final hard copy from microfilm should be of high quality and produced at high rate.

Vendors are currently being contacted to submit bids on equipment which will meet the above specifications.

REFERENCES

[1] Hart, J. F., et al. Computer Approximations. New York: Wiley and Sons, 1968.

[2] ILLIAC IV Quarterly Progress Report, January, February, and March, 1969. DCS Report No. 339, ILLIAC IV Document No. 219. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

[3] Dvoretzky, A. "On Stochastic Approximation." Proceedings of the Third Berkeley Symposium on Mathematical Statistics and Probability, I. 1965, pp. 39-55.

[4] Venter, J. H. "On Dvoretzky Stochastic Approximation Theorems." Annals of Mathematics and Statistics, Vol. 37, 1966, pp. 1534-1544.

[5] Stevens, James E. "A Kalman-Filter Tracking Program for ILLIAC IV." ILLIAC IV Document No. 222, DCS File No. 804, (August 13, 1969).

THESES

Allegre, Nicole. "TESLA, A Control Language for Logic Simulations of Digital Circuits." Master's thesis, DCS Report No. 347. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Flowerdew, Stanley J. "An Analysis of Some Eulerian Methods for One Dimensional, Inviscid, Compressible Dynamics." Master's thesis, DCS Report No. 352. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Lermit, Raymond J. "An Error Analysis of Solutions to Sparse Linear Programming Problems." Master's thesis, DCS Report No. 351. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Kraska, Paul W. "Array Storage Allocation." DCS Report No. 344. (August 1, 1969).

DOCUMENTS

Beals, Alan J., et al. "The Automatic Generation of Floyd Production Syntactic Analyzers." DCS Report No. 350. (September 9, 1969).

Bernhard, Winfried H. "A Matrix Inversion Program for ILLIAC IV." ILLIAC IV Document No. 229, DCS File No. 814, (July 8, 1969).

Knowles, Michael. "A Shadow Algorithm for Computer Graphics." ILLIAC IV Document No. 227, DCS File No. 811, (September 22, 1969).

Marceau, I. W., et al. "Linear Programming on ILLIAC IV." ILLIAC IV Document No. 225, DCS File No. 808, (September 1, 1969).

Matsushita, Y. "Hidden Lines Elimination for A Rotating Object." ILLIAC IV Document No. 220, DCS File No. 801, (July 2, 1969).

Stevens, James E. "A Kalman-Filter Tracking Program for ILLIAC IV." ILLIAC IV Document No. 222, DCS File No. 804, (August 13, 1969).

Wang, Paul J. "Romberg's Method in Numerical Quadrature." ILLIAC IV Document No. 223, DCS File No. 806, (July 1, 1969).

Yasui, Toshio. "Programming the Tillotson Equation of State on ILLIAC IV." ILLIAC IV Document No. 224, DCS File No. 807, (August 20, 1969).

CORRECTIONS

The following theses and documents were not mentioned in previous QPR's:

Gaffney, John L., Jr. "TACOS: A Table Driven Compiler-Compiler System." Master's thesis, DCS Report No. 325. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Gold, David E. "A Model for Linear Programming Optimization of I/O-Bound Programs." Master's thesis, DCS Report No. 340. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Graham, Marvin L. "The Role of Input/Output in a Computer System." ILLIAC IV Document No. 221, DCS File No. 800, (June 27, 1969).

Heimerdinger, W. L. "String Processing on a Parallel Computer." DCS Report No. 299, (January 13, 1969).

Horsman, Larry. "Design Considerations for Multilayer Transmission Line Circuit Boards." DCS Report No. 254, (January 2, 1968).

6. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL LANGUAGES

(Supported in part by the National Science Foundation under Grant No. NSF-GJ-217.)

6.1 Computerized Mathematics

The proposed paper on the completeness of resolution with merging and set of support when tautologies are discarded is nearly complete. We have also been reading some new articles on automatic theorem proving and searching for material on higher order logical systems that might be applicable to higher order methods of automatic deduction.

(L. J. Henschen)

6.2 Numerical Solution of Singular Integral Equations

The linear singular equation with a Cauchy kernel has an analytical solution, if one exists, in the functional space of Holder continuous functions for some fixed exponent μ, μ a positive constant. However, in order to obtain a uniform approximation theory, it is desirable to have a class of functions which will include all the possible Holder classes, and work has been directed toward this goal.

A promising solution seemed to be the Dini-Lipschitz class of functions. However there arose difficulties in showing the existence of the Cauchy principal value of a Hilbert transform of functions in this class. The difficulty here seems to be due to the fact that there is no bound to the slowness with which the modulus of continuity $\omega(f,\delta)$, the function can approach zero as $\delta \to 0+$. This problem appears to be solved if we modify the class somewhat to require a bound on this property, e.g.,

$$\omega(f,\delta) = 0\left(\left(\frac{1}{\log 1/\delta}\right)^{1+\epsilon}\right)$$

for arbitrary $\epsilon > 0$, as $\delta \to 0+$. This property is currently being investigated.

(A. McInnes)

6.3 Study of Methods of Selection of Quotient Digits During Digital Division

For the class of division techniques being studied, it is possible to select quotient digits based upon an estimate of the divisor and the shifted partial remainder. Let $\hat{d}$ and $\hat{rp}$ denote these estimates of the divisor and

shifted partial remainder, respectively. Quotient digits may be determined by completely combinational logic with $\hat{d}$ and $r\hat{p}$ as inputs and the set of Boolean functions, $f_i(\hat{d},r\hat{p})$ as outputs. The index, i, ranges over all possible quotient digits, 0 through n. This structure may be analized as a multiple output logic network.

One goal of this research is to determine estimates of the cost of such structures. It was decided that a minimal sum-of-products definition of each function, $f_i(\hat{d},r\hat{p})$ would be a useful indication of the cost. The product is minimal in the sense of requiring the minimum number of literals. Since no more than one output will be simultaneously true, the total network may be minimized by minimizing each function separately. The bulk of this quarter was devoted to the development of computer programs with which to perform this analysis.

The program QUOSEL-03 described in previous reports was modified to produce a minterm definition of each quotient region, i.e., to produce each function, $f_i(\hat{d},r\hat{p})$. The minterm is formed by concatenating the bit string representation of $\hat{d}$ with the bit string representation of $r\hat{p}$. Each set of minterms is then used as data for a Boolean minimization program developed by V. G. Tareski of this Department. The program produces the prime implicants together with constraint equations which define all possible coverings. This minimization program is quite rapid. For example, minimization of 765 true minterms of 15 variables requires 11.3 seconds of CPU time on the IBM 360/75. The upper bound on the running time varies as the square of the number of minterms.

The constraint equations are fed to an integer linear program which finds a minimal covering. This algorithm and program were developed by T. Ibaraki, T. K. Liu, C. R. Baugh, and S. Muroga. [1,2] This program is also very efficient. For example, it can find a minimal covering of 150 variables, 40 equations in 1.5 seconds.

To date, the programs have been used to study a radix 16 structure for divisors in the range 0.5 to 1. . The results are still being studied; however, it appears that the minimum number of prime implicants required to define the function $f_i(\hat{d},r\hat{p})$ is approximately 12 i, where i is the value of the quotient digit.

[1] Tso-Kai Liu, "A Code for Zero-One Integer Linear Programming by Implicit Enumeration (A Programming Manual for ILLIP,)" Dept. of Computer Science, Report No. 302, December, 1968.

[2] T. Ibaraki, et al, "An Implicit Enumeration Program for Zero-One Integer Programming," Dept. of Computer Science, Report No. 305, January, 1969.

For a divisor in the range 0.75 to 1.125 the minimum number of prime implicants required to define $f_i(\hat{d},\hat{rp})$ is approximately 7 i. This divisor range is of practical importance in a method which includes the following preliminary operation:

1) If $1/2 \leq d < 3/4$ multiply divisor and dividend by 3/2.
2) If $3/4 \leq d < 1$, multiply divisor and dividend by 1.

The minimization programs are now also being applied to other schemes which require a table look up of an estimate of the inverse of the divisor.

(D. E. Atkins)

6.4 Automatic Function Generation

During this quarter, work on a computer simulation of previously developed algorithms was begun. A single precision random number generator provided in the IBM 360/75 software package was extended to double precision; the samples of pseudo-random numbers generated pass the standard chi-square and Kolmogorov tests. The algorithms have been coded mostly in Fortran IV; some Assembly Language was used where convenient. From the sample of 2^{16} pseudo-random operands tested, it appears that theoretically predicted asymptotic results are verified.

Some work was begun late in this quarter involving a study of implementation of the algorithms. Some minor changes in the algorithms are required and corresponding changes must be made in the simulation code before the final statistical samples are completed.

(B. G. De Lugish)

6.5 NUCLEOL

During the summer, the interface between NUCLEOL and PL/1 was developed, and some of the basic tree algorithms were tested by the system. Simple kinds of tree transformation algorithms have also been written and tested in the NUCLEOL language.

Current work is being done on the generalization of tree transformations.

(N. Bracha, K. Maruyama,
J. Nievergelt)

6.6 Graph Algorithm Research

During this quarter, a version of the Graph Algorithm Software Package (GASP) was finalized and put on the IBM 360 disk. The package contains two parts, GASP macros and GASP procedures.

The GASP user codes his graph algorithm with a mixture of PL/1 and GASP statements. This source code is input to the PL/1 preprocessor which uses GASP macros to replace GASP statements with PL/1 code. The final PL/1 program is compiled, and then link-edited with the precompiled GASP procedures.

It is also easy (but not efficient) to have the GASP procedures included in the source code, producing a single, self-contained PL/1 program.

(S. Chase)

6.7 Switching Theory and Logical Design

During this quarter, our group studied closely Davidson's branch-and-bound method* for the logical design of optimum networks (first the number of gates is minimized, then the sum of external input connections plus gate interconnections is minimized) of NAND-gates.

For an initial comparison of our implicit enumeration method with the branch-and-bound method, I ran Gimpel's 6- and 7-gate problems which Davidson had solved (actually I ran the duals of Gimpel's functions since my program designs NOR-gate networks). The branch-and-bound method solved these two problems on the CDC 1604 in 52 seconds and 131 seconds respectively. The implicit enumeration method, using the IBM 360/75I, solved the same problems in 2.3 seconds and 57.5 seconds respectively, assuming the program has no bugs.

In an attempt to speed up Baugh's implicit enumeration program which I have been working with, experiments were made to determine the percentage of total execution time consumed by each of the twenty subroutines. The conclusions of these experiments were somewhat helpful; but, due to the problems which arose in trying to time subroutines that execute in much less time than the smallest clock interval, the empirical results were probably not too accurate.

(J. Culliney)

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* E. S. Davidson, "An Algorithm for NAND Decomposition of Combinational Switching Functions", Department of Electrical Engineering and Coordinated Science Laboratory, CSL Report No. R-382, University of Illinois, (Ph.D. dissertation), 1968.

6.8 A Study of Implicit Iterative Procedure Due to H. L. Stone

During this quarter, I have done numerical experiments in order to determine the value of e_2 where

$$e_2 = \text{Max} \frac{\langle Ax, x \rangle}{\langle (A+B)x, x \rangle}$$

and

A is the problem matrix,

A + B is the modified matrix such that A + B = L·U.

All experiments show that $e_2 < 2$.

(A. Bracha)

7. COMPUTATIONAL PHYSICS

The technique of a "Simpson's rule" for conditional Wiener integrals (1) has been applied to the calculation of the three-particle term in a density expansion of the pair distribution function for a gas of interacting He^4 particles. This is a quantum mechanical problem and involves two exchange terms (pair exchange and cyclic exchange) as well as the direct term (no exchange). The Wiener integrals involved are expressed as multiple integrals of products of Wiener integrals which may be approximated by ordinary integrals over a group of parameters (the "Simpson's rule" approximation). These terms must be further integrated with respect to the position of the third particle. The resulting multiple integrals then consist of integrals over: path break points, parameters (for "Simpson's rule" approximation), and the third particle. The Monte Carlo method is employed.

FØRTRAN programs for the direct and cyclic exchange terms have been coded. The results agree with analytical expressions assuming a harmonic oscillator interaction between particles. The direct term is more problematic since there is no weight function for the third particle integration. A comparison with calculations by Harry Jordan (2) for the 6-12 potential shows poor agreement at small distances between particle 1 and 2. This is possibly due to insufficient number of breakpoints. The pair exchange program has not been coded yet but should involve problems similar to those of direct and cyclic terms.

Robert C. Jacobson
Lloyd D. Fosdick

(1) Lloyd D. Fosdick and Harry F. Jordan, Approximation of a Conditional Wiener Integral, 3 (1968), 1-16.

(2) Harry F. Jordan, Three-Particle Effects in the Pair Distribution Function for He^4 Gas.

8. SWITCHING THEORY AND LOGICAL DESIGN

(Supported in part by the National Science Foundation under Grant No. NSF-GJ-503 and also in part by the Department of Computer Science, University of Illinois, Urbana, Illinois).

One of the disadvantages of synthesis of an optimal switching network by integer programming is that the number of inequalities increases rapidly with the number of gates in the network. Since every network has some gates whose inputs are only external variables and the output functions which these gates can represent are fixed if the types of gates are specified, we can introduce some variables in the integer programming formulation to represent these gates in order to reduce the number of gates required in the formulation. Accordingly the number of inequalities and variables are greatly reduced. These variables are called pseudo-gates. Unfortunately, the introduction of the pseudo-gate has decreased the rate of convergence of our program. Therefore the idea of pseudo-gates is not implemented in the current version of our program.

A new scheme called chain-checking of inequalities has been used to check inequalities in our program. This scheme uses a column vector $\mathbf{t}$ such that the value of t_i is the inequality number of the inequality which should be checked after checking the i-th inequality. Therefore we have essentially chained together all inequalities which should be checked in each iteration and we can check from one inequality to another without going through those inequalities which need not be checked. The effect of chain-checking depends on the number of inequalities in the problem. For problems with six to seven hundred inequalities, the computation time is reduced by one half.

The optimum networks of 1-bit adder have been obtained by using all interconnection formulation. If we use only NOR gates, the optimal network requires 8 gates and 23 connections. If we use NOR and AND gates, the optimum network requires 7 gates and 16 connections. If we use NOR and NAND gates, the optimum network requires 8 gates and 17 connections.

T. K. Liu
L. E. Shiau

An expository paper of Davidson's thesis has been prepared. This paper is nearly completed. The computational efficiency of his algorithm was investigated using a FORTRAN program for the IBM 360/75. Although this program does not include all of his sophisticated schemes, certain results show that his algorithm is very good in computation time, assuming no bugs in the program. For example, the optimal 1-bit adder with NOR gates can be solved in 46.21 seconds under the restriction of fan-ins and fan-outs of at most three. (The optimal network has 9 gates and 18 connections in six different configurations).

T. Nakagawa

Speed-up of Baugh's all-interconnection NOR program, which is currently being used to solve 6-, 7- and 8- gate problems of 4 variables were investigated. Two approaches were taken. The first was to directly time the different parts of the program to pinpoint the most time-consuming sections for closer examination. The second approach, not yet completed, is to review the entire program and algorithm in hopes of discovering possible improvements either in the form of algorithm changes or programming gimmicks. Application of the results of the first approach has not yet been attempted.

J. Culliney

The investigation of pseudo-threshold logic was continued. The emphasis in this quarter focused on the implementation of the algorithm to enumerate optimum structures for pseudo-threshold functions and also trinal pseudo-threshold functions. The algorithm for obtaining the structure consists of a sequence of linear programming problems. The algorithm for enumerating the set of representative functions of the NPN equivalence classes consists of obtaining all optimum solutions to a zero-one integer programming problem. The optimum structures

have been tabulated for all representative functions of the NPN class of pseudo-threshold functions of 6 or fewer variables and the NPN class of trinal pseudo-threshold functions of 5 or fewer variables.

R. C. Baugh

F. Chen finished his Ph.D. thesis work on an algorithm to design an optimum network of two levels with multiple outputs, using only AND and OR gates. This is an extension of the work of Bartee and McCluskey where AND gates and OR gates are not mixed in each level. Extending multiple-output prime implicants, he introduced a few algebraic concepts, the collection of which is called a sufficient set of MO elements. Then integer programming formulation is used to find an optimum combination of MO elements.

R. C. Baugh continued his Ph.D. thesis work on pseudo-threshold functions.

Chain-checking of inequalities appears to be significant because it can be applied to not only logical design but also general (0,1)-variable integer programming problems. Larger size integer programming problems can be solved than before.

Logical design problem by integer programming for MOS circuits is started to consider. Since in this case each gate (often called a cell) can represent a complicated negative function, the design problem seems more difficult. But conventional switching theory appears powerless. An integer programming approach seems promising.

S. Muroga

9. SOUPAC SECTION
(Statistically Oriented Users Programming and Consulting)

During the period July 1 through September 30, 1969, the Statistical Consultants were concerned with making numerous refinements in the SOUPAC system; three new programs were added, MVT (Multiprocessing with a Variable Number of Tasks) was implemented, and research began on converting SOUPAC to run in variable size partitions. The SOUPAC monitor is being reworked to a string of overlays, thereby cutting down its size.

The new programs are MISSING DATA CORRELATIONS, JACOBI - an eigenvalue-eigenvector routine, and PROBIT - a maximum likelihood regression analysis. Progress was made on the plotting routine, the ECONOMETRICS program, and a RANDOM NUMBER GENERATOR. The latter two programs will be available soon. The TRANSFORMATIONS program now handles missing data (distinguishes blanks from zeros) as do several other SOUPAC programs.

There have been a number of invitations for members of the SOUPAC staff to give talks or lectures to statistically oriented groups. Some of these have been scheduled for October and November. The following courses have requested materials for use in classes and SOUPAC instruction will be part of the course:

Psychology 306, 332, and 494
Sociology 185 and 201
Recreation 402

As early as August, the frequency of use of the SOUPAC programs has been as high as 50 jobs per day. We expect this frequency to continue and in fact to increase as the year progresses and dissemination of information about the new SOUPAC system becomes more readily available.

Joan A. Mills
Research Programmer

10. IBM SYSTEM/360 SERVICE

(Supported in Part by the National Science Foundation under Grant No. NSF-FP-7634.)

10.1 Log Summaries

Table I - IBM 360/20
Summary of Use
July, 1969

Scheduled Engineering	16:04
Unscheduled Engineering	22:01
Maintenance	2:36
Production	401:47
Idle	66:25
Total	482:30

Table II - IBM 360/20
Summary of Machine Errors
July, 1969

2560 MFCM	6
2203 Printer	3
Total	9

Table I - IBM 360/50-75

Summary of Use

July, 1969

Scheduled Engineering		32:23:54	
Unscheduled Engineering		30:53:00	
Idle		10:45:11	
		Subtotal	74:02:05
Total Use			
Training and Education		94:39:27	
System Improvement and Modifications		122:53:21	
System Updating		11:54:40	
University Administrative Overhead Use		1:57:32	
Overhead		:34	
Refund		61:08:47	
Customer Use			
In System	234:35:13		
Special Short Shots	6:08:45		
Customer Use Total		240:43:58	
		Total Use	533:18:19
		Total Time	607:20:24

Table II - IBM 360/50-75

Summary of Errors

July, 1969

Software	5
75 CPU	2
2314 Disk	1
2821 Printer Control	1
1443 Printer	1
Ross Problem	1
Total	11

IBM 360/20 TABLE III JULY, 1969

MINUTES--360/20 REAL TIME

EPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AE	19	9	28	64	140	204
CCY	17	5	22	133	42	175
GL	0	12	12	0	142	142
GEC	15	37	52	323	429	752
GR CN	0	5	5	0	32	32
NS	0	26	26	0	146	146
STR	0	18	18	0	94	94
ADM	1	2	3	6	60	66
ECBSP	0	1	1	0	21	21
INRES	0	4	4	0	120	120
E	38	61	99	440	692	1132
HL	0	114	114	0	1353	1353
LASS	0	43	43	0	329	329
RC	0	25	25	0	215	215
SL	0	20	20	0	190	190
URLAB	0	1	1	0	40	40
LS	136	77	213	1050	410	1460
b	0	6	6	0	93	93
CON	0	2	2	0	92	92
D	1	31	32	1	780	781
OPSY	10	0	10	63	0	63
E	14	51	65	46	370	416
NGADM	0	9	9	0	159	159
NGCST	0	25	25	0	432	432
NTDM	0	12	12	0	34	34
IN	4	28	32	33	293	326
F	0	4	4	0	35	35
LOG	0	1	1	0	9	9
COL	0	7	7	0	105	105
GA	0	3	3	0	85	85
FD	0	65	65	0	3557	3557
ORT	0	7	7	0	44	44
IR	0	18	18	0	62	62
ILDMH	0	1	1	0	78	78
IR	0	9	9	0	101	101
RADM	0	2	2	0	10	10
TH	1	9	10	2	9	11
MTRL	0	99	99	0	761	761
BIN	0	1	1	0	1	1
M	32	74	106	115	743	858
MTG	0	5	5	0	63	63
MSIC	16	1	17	111	1	112
NCE	5	18	23	12	157	169
CR	0	4	4	0	266	266
PM	0	23	23	0	263	263
PYP	0	9	9	0	39	39
PYCS	0	69	69	0	535	535
PYSL	0	1	1	0	1	1
PYX	0	25	25	0	469	469
FLS	0	3	3	0	10	10
POVST	0	14	14	0	315	315
PYCP	7	100	107	56	1646	1702
RC	0	20	20	0	467	467

SCONS	0	3	3	0	13	13
SGS	0	6	6	0	112	112
SOC	0	25	25	0	692	692
SOCW	0	5	5	0	58	58
SRL	5	5	10	77	40	117
SSUAD	0	1	1	0	5	5
SWS	0	16	16	0	51	51
TAM	4	34	38	9	145	154
UOSCR	0	5	5	0	96	96
VPH	0	9	9	0	131	131
VPP	0	3	3	0	28	28
VTED	0	2	2	0	16	16
ZOOL	0	5	5	0	259	259
SUBTOTAL	325	1335	1660	2541	18186	20727
OCSSYS[3]	0	293	293	0	2762	2762
REFUND[4]	0	2	2	0	16	16
UADP[5]	0	1	1	0	2	2
XDCS[6]	0	9	9	0	61	61
XMAINT[7]	0	169	169	0	6528	6528
TOTAL	325	1809	2134	2541	27555	30096

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 University Administrative Overhead Use
6 System Updating
7 System Maintenance

IBM 360/75 TABLE III JULY, 1969

SECONDS--360/75 REAL TIME

EPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AE	296	225	521	11803	10342	22145
CCY	1090	27	1117	21454	1282	22736
DV	0	8	8	0	441	441
GE	0	132	132	0	3379	3379
GEC	121	350	471	4848	27701	32549
GRDN	0	150	150	0	11330	11330
NS	0	50	50	0	1205	1205
RCH	176	0	176	8117	0	8117
STR	0	98	98	0	3856	3856
ADM	12	19	31	684	-838	-154
ECBSR	0	37	37	0	3061	3061
INKES	0	13	13	0	404	404
DA	0	2	2	0	31	31
E	1629	1316	3145	57618	59826	117444
HE	1	1800	1801	93	98680	98773
LASS	0	2327	2327	0	81399	81399
OLCOM	0	-1	-1	0	-16	-16
RC	0	168	168	0	9056	9056
SL	0	201	201	0	10789	10789
.S	5400	444	5844	112806	32340	145146
S	0	69	69	0	3483	3483
CON	0	46	46	0	1583	1583
D	115	156	271	3010	5871	8881
DADM	0	41	41	0	4043	4043
DPSY	86	0	86	1326	0	1326
E	500	755	1255	11954	34550	46504
NGADM	0	280	280	0	21323	21323
NGCST	0	411	411	0	23565	23565
NTCM	0	26	26	0	731	731
N	167	78	245	12815	2969	15784
OR	0	6	6	0	-27	-27
P	0	33	33	0	1220	1220
ONE	11	7	18	562	139	701
OOG	0	31	31	0	847	847
OOL	0	112	112	0	6556	6556
OA	0	17	17	0	485	485
PC	0	2	2	0	30	30
PD	0	27	27	0	1834	1834
RT	0	36	36	0	2155	2155
IR	0	196	196	0	9511	9511
ILDMH	0	82	82	0	10816	10815
IR	0	65	65	0	2288	2288
IADM	0	18	18	0	948	948
MTH	24	62	86	3916	3800	7716
MTRL	0	1419	1419	0	79319	79319
MBIC	0	53	53	0	1716	1716
M	567	871	1438	33082	25862	58944
MTG	0	26	26	0	583	583
MSIC	236	10	246	9591	355	9946
NCE	47	248	295	1419	11467	12886
OR	0	231	231	0	11943	11943
PM	0	123	123	0	5520	5520
PYE	0	180	180	0	12171	12171

PHYCS	0	844	844	0	33271	33271
PHYSL	-1	66	65	-301	1232	931
PHYX	0	452	452	0	51255	51255
POLS	5	142	147	116	8478	8594
PROVST	0	49	49	0	3495	3495
PSYCH	47	912	959	2345	57405	59750
REC	0	60	60	0	3514	3514
SCONS	0	46	46	0	2166	2166
SGS	0	232	232	0	6426	6426
SOC	0	120	120	0	6219	6219
SRL	338	204	542	17437	10886	28323
SWS	0	500	500	0	18071	18071
TAM	78	275	353	3947	12422	16369
UOSCR	0	77	77	0	2093	2093
USGS	0	1	1	0	111	111
VPH	0	12	12	0	446	446
VPP	0	37	37	0	846	846
VTED	0	23	23	0	837	837
ZOOL	0	143	143	0	5541	5541
SUBTOTAL	11145	17278	28423	318642	866638	1185280
DCSSYS[3]	0	3438	3438	0	442401	442401
CVRHED[4]	0	2	2	0	34	34
REFUND[5]	0	471	471	0	220127	220127
UADP[6]	0	42	42	0	7052	7052
XDCS[7]	0	137	137	0	42880	42880
XMAINT[8]	0	29	29	0	266525	266525
XSSS[9]	0	772	772	0	22125	22125
TOTAL	11145	22169	33314	318642	1867782	2186424

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

Table I - IBM 360/50-75

Summary of Use

August, 1969

Scheduled Engineering		33:36:50	
Unscheduled Engineering		5:40:00	
Air Conditioning		00:31:30	
		Subtotal	39:48:20
Total Use			
Training and Education		61:47:55	
System Improvements and Modifications		105:13:32	
System Updating		17:03:17	
University Administrative Overhead Use		00:34:21	
Overhead		00:00:16	
Refund		5:34:48	
Customer Use			
In System	406:37:23		
Special Short Shots	7:23:48		
Customer Use Total		414:01:11	
		Total Use	433:15:20
		Total Time	473:03:40

Table II - IBM 360/50-75

Summary of Errors

August, 1969

Software	2
Air Conditioning	2
2316 Disk Pack	1
1501 Card Reader	1
2821 Printer Control	1
50 CPU	2
Total	9

IBM 360/20 TABLE III AUGUST 1969

MINUTES--360/20 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	9	8	17	75	134	209
ACCY	46	8	54	153	74	227
ADV	0	1	1	0	14	14
AGE	0	11	11	0	151	151
AGEC	1	75	76	3	859	862
AGRON	0	15	15	0	64	64
ANS	4	24	28	40	171	211
ARCH	1	0	1	8	0	8
ASTR	0	9	9	0	74	74
BADM	0	1	1	0	22	22
BINRES	0	1	1	0	1	1
CE	19	53	72	222	943	1165
CERL	0	12	12	0	304	304
CHE	0	66	66	0	917	917
CLASS	0	1	1	0	8	8
CRC	0	14	14	0	601	601
CSL	0	18	18	0	227	227
DCS	38	62	100	67	285	352
DS	0	17	17	0	123	123
ECON	0	7	7	0	47	47
ED	1	11	12	9	84	93
EDPSY	3	0	3	14	0	14
EE	6	42	48	18	442	460
ENGADM	0	8	8	0	58	58
ENGCST	0	14	14	0	47	47
ENGH	2	0	2	6	0	6
ENTOM	0	6	6	0	9	9
FIN	3	6	9	58	8	66
FT	0	1	1	0	10	10
GEOL	0	10	10	0	42	42
HEC	0	11	11	0	446	446
HORT	0	11	11	0	57	57
ICR	0	26	26	0	516	516
ILLDMH	0	2	2	0	24	24
ILR	0	6	6	0	81	81
INADM	0	3	3	0	50	50
LIBS	0	3	3	0	23	23
MATH	1	14	15	1	33	34
MATRL	0	77	77	0	999	999
MCBIO	0	1	1	0	7	7
ME	17	31	48	79	195	274
MKTG	0	2	2	0	16	16
MUSIC	22	8	30	106	72	178
NHS	0	3	3	0	4	4
NUCE	4	30	34	15	377	392
OIR	0	17	17	0	255	255
PEM	0	21	21	0	257	257
PHYB	0	4	4	0	7	7
PHYCS	0	38	38	0	312	312
PHYSL	0	5	5	0	10	10
PHYX	0	6	6	0	56	56
POLS	0	10	10	0	132	132
PRCVST	0	10	10	0	174	174

PSYCH	3	76	79	30	601	631
REC	C	4	4	0	24	24
SCCNS	C	1	1	0	2	2
SGS	C	23	23	0	474	474
SCC	C	24	24	0	926	926
SOCW	C	10	10	0	119	119
SRL	C	7	7	0	126	126
SWS	C	6	6	0	60	60
TAM	1	23	24	5	183	188
UOSCR	C	9	9	0	145	145
USGS	C	1	1	0	2	2
VPP	C	1	1	0	6	6
VTED	C	12	12	0	442	442
SUBTOTAL	181	1037	1218	909	12932	13841
DCSSYS[3]	C	220	220	0	2090	2090
REFUND[4]	C	3	3	0	41	41
XDCS[5]	C	5	5	0	16	16
XMAINT[6]	C	380	380	0	15257	15257
TOTAL	181	1645	1826	909	30336	31245

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 System Updating
6 System Maintenance

IBM 360/75 TABLE III AUGUST 1969

SECONDS--360/75 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	231	221	452	14767	11394	26161
ACCY	515	152	667	13596	8045	21641
ADV	0	30	30	0	1719	1719
AGE	0	301	301	0	10175	10175
AGEC	146	570	716	7770	38187	45957
AGRON	0	177	177	0	5642	5642
ANS	19	50	69	798	1085	1883
ARCH	121	0	121	5074	0	5074
ASTR	0	96	96	0	5871	5871
BADM	0	19	19	0	1469	1469
BECBSR	0	3	3	0	140	140
BINRES	0	47	47	0	2717	2717
BICPH	0	28	28	0	746	746
BOT	0	26	26	0	795	795
CE	693	1803	2496	29799	82061	111860
CERL	0	104	104	0	5017	5017
CELSA	0	11	11	0	633	633
CHE	0	1040	1040	0	55185	55185
CIRCE	0	3	3	0	61	61
CLASS	0	16	16	0	2333	2333
COLCOM	0	15	15	0	307	307
CRC	0	100	100	0	7050	7050
CSL	0	162	162	0	8086	8086
DCS	1559	838	2397	50457	54870	105327
DS	0	140	140	0	16174	16174
ECON	0	49	49	0	1746	1746
ED	37	170	207	1147	7261	8408
EDADM	0	19	19	0	991	991
EDPSY	124	8	132	2170	425	2595
EE	140	781	921	5945	50706	56651
ENGADM	0	185	185	0	13597	13597
ENGCST	0	173	173	0	12461	12461
ENGH	14	0	14	522	0	522
ENTOM	0	34	34	0	1061	1061
FIN	38	8	46	5205	388	5593
FOR	0	10	10	0	266	266
FT	0	20	20	0	689	689
GENE	0	7	7	0	128	128
GEOG	0	7	7	0	1213	1213
GEOL	0	84	84	0	5101	5101
GSA	0	2	2	0	59	59
HEC	0	14	14	0	619	619
HED	0	52	52	0	25840	25840
HONORS	0	10	10	0	915	915
HORT	0	33	33	0	1960	1960
ICR	0	260	260	0	11633	11633
IE	30	0	30	547	0	547
ILLCMH	0	93	93	0	12954	12954
ILR	0	29	29	0	1241	1241
INADM	0	33	33	0	3394	3394
LIBS	0	39	39	0	2354	2354
MATH	5	195	200	247	7187	7434
MATRL	0	1708	1708	0	114741	114741

MCBIO	C	43	43	C	1247	1247
MCCL	C	6	6	0	146	146
ME	233	230	463	7575	8336	15911
MILPCL	C	4	4	0	126	126
MKTG	0	12	12	0	208	208
MUSIC	245	27	272	20606	1050	21656
NHS	C	1	1	0	28	28
NUCE	70	279	349	2176	23923	26099
OIR	C	163	163	0	4896	4896
PEM	C	60	60	0	2925	2925
PHYB	C	132	132	0	5715	5715
PHYCS	C	707	707	0	26579	26579
PHYSL	0	64	64	0	859	859
PHYX	C	280	280	0	23591	23591
PCLS	5	143	148	406	6889	7295
PROVST	C	25	25	0	1986	1986
PSYCH	68	839	907	4615	62043	66658
REC	36	70	106	2535	6537	9072
SCCNS	0	32	32	0	1590	1590
SGS	C	184	184	0	7085	7085
SOC	C	161	161	0	15157	15157
SRL	273	245	518	15918	14043	29961
SWS	C	820	820	0	30867	30867
TAM	94	290	384	3972	18377	22349
UCSCR	C	25	25	0	2344	2344
USGS	C	13	13	0	257	257
VPF	C	6	6	C	83	83
VPP	C	57	57	C	1028	1028
WTED	C	70	70	0	4064	4064
ZOOL	C	100	100	0	4190	4190
SUBTOTAL	4696	15063	19759	195847	874861	1070708
DCSSYS[3]	C	3174	3174	0	378812	378812
OVRHED[4]	C	2	2	0	16	16
REFUND[5]	C	212	212	0	20088	20088
UADP[6]	C	43	43	0	2061	2061
XDCS[7]	C	197	197	0	61397	61397
XMAINT[8]	0	25	25	0	143310	143310
XSSS[9]	0	755	755	0	26628	26628
TOTAL	4696	19471	24167	195847	1507173	1703020

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

IEM 1800 TABLE III AUGUST 1969

SECONDS--1800 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGRON	C	2	2	0	549	549
ARCH	5	C	5	2396	0	2396
BIOPH	0	25	25	0	9205	9205
CE	0	7	7	0	24105	24105
COLCOM	C	13	13	0	4996	4996
CSL	0	6	6	0	785	785
DCS	C	1	1	0	5	5
EE	C	22	22	0	4772	4772
NUCE	C	7	7	0	9264	9264
SUBTOTAL	5	83	88	2396	53681	56077
DCSSYS[3]	C	148	148	0	49784	49784
REFUND[4]	C	8	8	0	1608	1608
TOTAL	5	239	244	2396	105073	107469

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error

Tabel I - IBM 360/20

Summary of Use

September, 1969

Scheduled Engineering		14:29
Unscheduled Engineering		21:52
Maintenance		4:34
Production		202:57
Idle		254:08
	Total	498:00

Table II - IBM 360/20

Summary of Machine Errors

September, 1969

2560 MFCM		4
	Total	4

Table I - IBM 360/50-75

Summary of Use

September, 1969

Scheduled Engineering		21:32:27	
Unscheduled Engineering		20:07:20	
Air Conditioning		80:29:00	
		Subtotal	122:08:47
Total Use			
Training and Education		23:67:59	
System Improvements and Modifications		66:40:63	
System Updating		72:32:13	
University Administrative Overhead Use		00:19:41	
Overhead		00:05:44	
Refund		03:01:77	
Customer Use			
In System	150:60:79		
Special Short Shots	02:77:50		
Customer Use Total		154:18:69	
		Total Use	320:67:66
		Total Time	443:42:86

Table II - IBM 360/50-75

Summary of Errors

September, 1969

Hardware Error		1
Air Conditioning		2
Power Supply		1
2540 Punch and Reader Checks		1
2831 Printer Control Unit		1
Voltage Problem		1
	Total	7

IBM 360/20 TABLE III SEPTEMBER 1969

MINUTES--360/20 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	10	1	11	101	6	107
ACCY	10	7	17	18	132	150
ADV	0	1	1	0	29	29
AGE	0	34	34	0	479	479
AGEC	3	35	38	133	260	393
AGRON	11	7	18	126	23	149
ANS	1	14	15	10	46	56
ASTR	0	4	4	0	27	27
BADM	1	0	1	2	0	2
BINRES	0	3	3	0	8	8
CE	5	69	74	39	863	902
CERL	0	22	22	0	90	90
CEUSA	0	5	5	0	12	12
CHE	0	32	32	0	274	274
CRC	0	5	5	0	21	21
CSL	0	6	6	0	67	67
DATLOG	0	1	1	0	2	2
DCS	147	47	194	226	298	524
DS	0	30	30	0	206	206
DSEA	0	2	2	0	51	51
ECON	0	5	5	0	85	85
ED	0	31	31	0	337	337
EDADM	0	1	1	0	18	18
EDPSY	2	0	2	23	0	23
EE	0	25	25	0	224	224
ENGADM	0	14	14	0	96	96
ENGCST	0	5	5	0	19	19
ENGH	4	0	4	21	0	21
FIN	4	2	6	44	14	58
FT	0	2	2	0	21	21
GENE	16	0	16	69	0	69
GEOG	0	1	1	0	36	36
GEOL	0	11	11	0	51	51
HEC	0	1	1	0	50	50
HED	0	8	8	0	182	182
HORT	0	3	3	0	10	10
ICR	0	21	21	0	251	251
ILLDMH	0	2	2	0	71	71
ILR	0	4	4	0	24	24
INADM	0	2	2	0	29	29
LIBS	0	1	1	0	3	3
MATH	0	5	5	0	25	25
MATRI	0	63	63	0	681	681
ME	5	15	20	19	76	95
MUSIC	2	3	5	22	9	31
NHS	0	1	1	0	1	1
NUCE	2	28	30	20	266	286
OIR	0	20	20	0	326	326
ORME	0	1	1	0	50	50
PEM	0	9	9	0	110	110
PHYB	0	3	3	0	28	28
PHYCS	0	38	38	0	389	389
PHYSI	0	1	1	0	4	4

PHYX	0	21	21	0	188	188
POLS	0	7	7	0	32	32
PROVST	0	1	1	0	8	8
PSYCH	0	42	42	0	584	584
REC	1	3	4	39	195	234
SGS	0	13	13	0	325	325
SOC	0	9	9	0	168	168
SWS	0	3	3	0	25	25
TAM	0	10	10	0	22	22
UOSCP	0	13	13	0	247	247
VPH	0	1	1	0	3	3
VTED	0	20	20	0	177	177
ZOOL	0	2	2	0	7	7
SUBTOTAL	224	796	1020	912	8361	9273
DCSSYS[3]	0	254	254	0	2714	2714
REFUND[4]	0	5	5	0	88	88
UADP[5]	0	2	2	0	65	65
XDCS[6]	0	4	4	0	42	42
XMAINT[7]	0	349	349	0	17549	17549
TOTAL	224	1410	1634	912	28819	29731

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 University Administrative Overhead Use
6 System Updating
7 System Maintenance

SECONDS--360/75 REAL TIME

Sequential System

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	114	30	144	3926	2775	6701
ACCY	239	35	274	4280	2941	7221
AGE	1	271	272	54	8308	8362
AGEC	0	609	609	0	54631	54631
AGRON	155	119	274	3118	3182	6300
ANS	0	86	86	0	2398	2398
ASTR	0	45	45	0	2255	2255
BADM	0	2	2	0	135	135
BINRES	0	38	38	0	3004	3004
BIOPH	0	3	3	0	9	9
BOT	0	13	13	0	408	408
CE	106	955	1061	7144	40488	47632
CERL	0	15	15	0	422	422
CERLSA	0	75	75	0	4947	4947
CHE	10	840	850	2407	46579	48986
CRC	0	37	37	0	1890	1890
CSI	0	58	58	0	4615	4615
DATLOC	0	4	4	0	95	95
DCS	606	318	924	28977	27984	56961
DS	0	148	148	0	7884	7884
ECON	27	20	47	572	1007	1579
ED	10	179	189	1007	7469	8475
EDADM	0	28	28	0	2291	2291
EDPSY	98	3	101	1269	183	1452
EE	0	239	239	0	11094	11094
ENGADM	0	146	146	0	10893	10893
ENGCST	0	62	62	0	4993	4993
ENGH	63	0	63	1354	0	1354
ENTOM	0	13	13	0	412	412
FIN	4	10	14	90	734	824
FOR	0	18	18	0	496	496
FT	0	36	36	0	1401	1401
GENE	65	0	65	1882	0	1882
GEOG	0	3	3	0	50	50
GEOL	0	51	51	0	2368	2368
HEC	0	10	10	0	613	613
HED	0	36	36	0	1278	1278
HORT	0	1	1	0	28	28
ICP	0	162	162	0	5378	5378
IE	1	0	1	28	0	28
ILLDMH	0	85	85	0	9321	9321
ILR	0	10	10	0	479	479
INADM	0	34	34	0	3701	3701
LIBS	0	10	10	0	522	522
MATH	0	39	39	0	1279	1279
MATPI	0	659	659	0	47404	47404
MCBIC	0	8	8	0	169	169
ME	62	126	188	2072	3611	5683
MKTG	0	25	25	0	1580	1580
MUSIC	19	-1	18	1305	-41	1264
NHS	0	9	9	0	302	302
NUCE	16	215	231	301	19366	19667
OIR	0	192	192	0	11725	11725

ORME	0	5	5	0	75	75
PEM	0	61	61	0	1622	1622
PHYB	0	117	117	0	4820	4820
PHYCS	0	570	570	0	35452	35452
PHYSL	0	43	43	0	814	814
PHYX	0	204	204	0	30421	30421
POLS	5	20	25	157	793	950
PROVST	0	5	5	0	140	140
PSYCH	15	481	496	1377	37320	38697
REC	34	8	42	3037	447	3484
SCONS	0	15	15	0	793	793
SGS	0	126	126	0	5422	5422
SOC	0	51	51	0	2453	2453
SPED	0	33	33	0	739	739
SRL	0	16	16	0	1277	1277
SWS	0	621	621	0	25170	25170
TAM	-1	100	99	-16	6493	6477
UOSCP	0	22	22	0	9955	9955
USGS	0	8	8	0	88	88
VPH	0	7	7	0	184	184
VTED	0	84	84	0	6548	6548
ZOOL	0	65	65	0	4327	4327
SUBTOTAL	1649	8791	10440	64341	540410	604751
OCSSYS[3]	0	2236	2236	0	232344	232344
OVRHED[4]	0	19	19	0	344	344
REFUND[5]	0	158	158	0	10896	10896
UADP[6]	0	11	11	0	1181	1181
XDCS[7]	0	176	176	0	261063	261063
XMAINT[8]	0	22	22	0	439700	439700
XSSS[9]	0	355	355	0	10667	10667
TOTAL	1649	11768	13417	64341	1496605	1560945

1 See list of departmental codes following
2 Training and Education
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4 System Use in Excess of User Estimated Usage
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6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

CENTISECONDS--360/75 PROCESSOR TIME
Multiprogramming (MVT) System

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	35	0	35	17796	0	17796
ACCY	133	0	133	13677	0	13677
AGE	14	52	66	14589	20151	34740
AGEC	0	25	25	0	19484	19484
AGRON	73	2	75	15691	2365	18056
ANS	0	6	6	0	570	570
ASTR	0	9	9	0	5205	5205
BINFES	0	1	1	0	412	412
BOT	0	1	1	0	1780	1780
CE	70	160	230	39783	87115	126898
CEUSA	0	6	6	0	8494	8494
CHE	22	149	171	56372	248207	304579
CPC	0	15	15	0	6851	6851
CSI	0	6	6	0	14054	14054
DCS	1580	109	1689	683576	189156	872732
DS	0	4	4	0	11992	11992
ECON	2	1	3	1419	45	1464
ED	1	18	19	1	8089	8090
EDADM	0	6	6	0	3926	3926
EDPSY	85	0	85	4902	0	4902
EE	0	41	41	0	33190	33190
ENGADM	0	14	14	0	15262	15262
ENGCST	0	24	24	0	86650	86650
ENGH	17	0	17	3436	0	3436
ENTOM	0	1	1	0	689	689
FOR	0	5	5	0	3271	3271
FT	0	5	5	0	2936	2936
GENE	38	0	38	15137	0	15137
GEOG	3	2	5	302	7	309
GEOL	0	14	14	0	18953	18953
HED	0	3	3	0	332	332
HORT	0	2	2	0	913	913
ICR	0	37	37	0	6181	6181
LIBS	0	1	1	0	89	89
MATH	0	3	3	0	699	699
MATRI	0	67	67	0	369886	369886
ME	66	9	75	13855	8748	22603
MUSIC	12	1	13	11592	460	12052
NUCE	2	27	29	519	27014	27533
OIR	0	83	83	0	25303	25303
PEM	0	6	6	0	516	516
PHYE	0	13	13	0	7582	7582
PHYCS	0	94	94	0	102700	102700
PHYSI	0	21	21	0	46847	46847
PHYX	0	24	24	0	74534	74534
PROVST	0	18	18	0	27541	27541
PSYCH	0	43	43	0	50179	50179
REC	10	1	11	463	5	468
SCONS	0	5	5	0	2314	2314
SGS	0	11	11	0	6246	6246
SOC	0	2	2	0	12	12
SOCW	0	1	1	0	9	9
SPI	0	7	7	0	3432	3432

SWS	0	110	110	0	101000	101000
TAM	20	13	33	166575	20175	186750
UOSCP	0	5	5	0	1282	1282
VPP	0	11	11	0	443	443
VTED	0	3	3	0	1118	1118
ZOOL	0	4	4	0	5876	5876
SUBTOTAL	2183	1301	3484	1059685	1680300	2739985
OCSSYS[3]	0	738	738	0	771896	771896
REFUND[4]	0	3	3	0	4062	4062
UADP[5]	0	1	1	0	1	1
XOCS[6]	0	43	43	0	6996	6996
XMAINT[7]	0	9	9	0	2726	2726
XSSS[8]	0	136	136	0	120258	120258
TOTAL	2183	2231	4414	1059685	2586239	3645924

3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 University Administrative Overhead Use
6 System Updating
7 System Maintenance
8 Special Short Shots

INPUT/OUTPUT REQUESTS--360/75

Multiprogramming (MVT) System

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	28	0	28	15664	0	15664
ACCY	129	0	129	15522	0	15522
ACE	14	48	62	13440	30968	44408
AGEC	0	17	17	0	34192	34192
AGRON	72	1	73	20640	2878	23518
ANS	0	5	5	0	1594	1594
ASTR	0	9	9	0	8037	8037
BINRES	0	1	1	0	522	522
BOT	0	1	1	0	1258	1258
CE	67	157	224	77059	131393	208452
CEUSA	0	6	6	0	4193	4183
CHE	19	147	166	11890	133362	145252
CRC	0	14	14	0	10512	10512
CSL	0	6	6	0	52443	52443
DCS	1573	104	1677	377569	107510	485079
DS	0	4	4	0	7228	7228
ECON	2	1	3	3194	248	3442
ED	0	13	13	0	7531	7531
EDADM	0	6	6	0	9969	9969
EDPSY	36	0	36	1692	0	1692
EE	0	41	41	0	43013	43013
ENGADM	0	11	11	0	26638	26638
ENGCST	0	22	22	0	78599	78599
ENGR	17	0	17	4652	0	4652
ENTOM	0	1	1	0	908	908
FOR	0	5	5	0	5834	5834
FT	0	4	4	0	9744	9744
GENE	38	0	38	23784	0	23784
GEOG	3	0	3	959	0	959
GEOL	0	13	13	0	17266	17266
HED	0	2	2	0	1215	1215
HORT	0	2	2	0	1296	1296
ICR	0	29	29	0	13559	13559
LIBS	0	1	1	0	184	184
MATH	0	3	3	0	1011	1011
MATPL	0	65	65	0	54389	54389
ME	66	9	75	27870	8098	35968
MUSIC	12	1	13	7565	945	8510
NUCE	2	27	29	2090	24952	27042
OIR	0	80	80	0	22682	22682
PEM	0	3	3	0	863	863
PHYB	0	13	13	0	10823	10823
PHYCS	0	89	89	0	68952	68952
PHYSI	0	20	20	0	35746	35746
PHYX	0	22	22	0	74400	74400
PROVST	0	12	12	0	71596	71596
PSYCH	0	34	34	0	45313	45313
REC	10	0	10	5655	0	5655
SCONS	0	4	4	0	7155	7155
SGS	0	11	11	0	9836	9836
SRL	0	7	7	0	14779	14779
SWS	0	110	110	0	117677	117677
TAM	20	13	33	14322	10999	25321

UOSCP	0	5	5	0	3107	3107
VPP	0	11	11	0	1411	1411
VTED	0	3	3	0	1911	1911
ZOOL	0	4	4	0	4732	4732
SUBTOTAL	2108	1217	3325	623567	1333461	1957028
OOSSYS [3]	0	705	705	0	886088	886088
REFUND [4]	0	3	3	0	1029	1029
XOOS [5]	0	39	39	0	83110	83110
XMAINT [6]	0	9	9	0	67801	67801
XSSS [7]	0	136	136	0	78958	78958
TOTAL	2108	2109	4217	623567	2450447	3074014

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 System Updating
6 System Maintenance
7 Special Short Shots

IBM 360/75 TABLE III SEPTEMBER 1969

UNITS CHARGED--360/75
Multiprogramming (MVT) System

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	34	0	34	11535	0	11535
ACCY	133	0	133	9931	0	9931
AGE	14	50	64	6777	16739	23516
AGEC	0	24	24	0	11828	11828
AGRON	72	1	73	9344	1751	11095
ANS	0	6	6	0	446	446
ASTR	0	9	9	0	3759	3759
BINRES	0	1	1	0	346	346
BOT	0	1	1	0	1060	1060
CE	70	158	228	30546	70163	100709
CEUSA	0	6	6	0	3229	3229
CHE	22	148	170	37427	137616	175043
CRC	0	15	15	0	3529	3529
CSL	0	6	6	0	16710	16710
DCS	1579	106	1685	385331	99180	484511
DS	0	4	4	0	7185	7185
ECON	2	1	3	1868	51	1919
ED	0	17	17	0	4988	4988
EDADM	0	6	6	0	4341	4341
EDPSY	82	0	82	2456	0	2456
EE	0	41	41	0	18555	18555
ENGADM	0	14	14	0	9730	9730
ENGCST	0	24	24	0	40750	40750
ENGR	17	0	17	1749	0	1749
ENTOM	0	1	1	0	348	348
FOR	0	5	5	0	2249	2249
FT	0	5	5	0	2381	2381
GENE	38	0	38	8913	0	8913
GEOG	3	1	4	249	1	250
GEOL	0	13	13	0	8853	8853
HED	0	3	3	0	402	402
HORT	0	2	2	0	597	597
ICP	0	30	30	0	5511	5511
LIBS	0	1	1	0	112	112
MATH	0	3	3	0	366	366
MATRL	0	67	67	0	154351	154351
ME	66	9	75	9051	4734	13785
MUSIC	12	1	13	4688	284	4972
NUCE	2	27	29	683	19118	19801
OIP	0	83	83	0	11091	11091
PEM	0	6	6	0	287	287
PHYB	0	13	13	0	4856	4856
PHYCS	0	89	89	0	57122	57122
PHYSI	0	20	20	0	19535	19535
PHYX	0	24	24	0	58457	58457
PROVST	0	14	14	0	39244	39244
PSYCH	0	40	40	0	27642	27642
REC	10	1	11	1454	1	1455
SCONS	0	5	5	0	1975	1975
SGS	0	11	11	0	4739	4739
SOC	0	2	2	0	3	3
SOCW	0	1	1	0	2	2
SRI	0	7	7	0	3300	3300

SWS	0	110	110	0	62565	62565
TAM	20	13	33	53022	9470	62492
UOSCP	0	5	5	0	1654	1654
VPP	0	11	11	0	345	345
VTED	0	3	3	0	1061	1061
ZOOI	0	4	4	0	2514	2514
SUBTOTAL	2176	1268	3444	575024	957126	1532150
DCSSYS[3]	0	726	726	0	462251	462251
REFUND[4]	0	3	3	0	2106	2106
XDCS[5]	0	39	39	0	18267	18267
XMAINT[6]	0	9	9	0	11176	11176
XSSS[7]	0	136	136	0	59864	59864
TOTAL	2176	2181	4357	575024	1510790	2085814

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 System Updating
6 System Maintenance
7 Special Short Shots

IBM 360/75 TABLE III SEPTEMBER 1969

MINUTES--SERVICE PROGRAMMING

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[3]	RES	TOTAL
AGEC	0	1	1	0	120	120
CE	0	2	2	0	450	450
ED	0	2	2	0	1410	1410
ET	0	3	3	0	1530	1530
GEOG	0	3	3	0	405	405
SUBTOTAL	0	11	11	0	3915	3915
TOTAL	0	11	11	0	3915	3915

1 See list of departmental codes following
2 Training and Education

IBM 360/75 TABLE III SEPTEMBER 1969

CARDS KEYPUNCHED

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
ACCY	1	2	3	50	300	350
ADV	0	1	1	0	800	800
AGEC	0	3	3	0	2650	2650
ANS	1	1	2	400	500	900
ASTR	0	3	3	0	3850	3850
CE	0	1	1	0	3700	3700
CHE	0	1	1	0	1000	1000
CRC	0	51	51	0	8400	8400
DCS	6	9	15	1350	4250	5600
DSEA	0	1	1	0	2000	2000
ED	2	9	11	2000	2800	4800
ENGCST	0	2	2	0	2300	2300
FIN	3	2	5	1100	400	1500
FT	0	4	4	0	600	600
GEOL	0	4	4	0	2900	2900
HORT	0	1	1	0	3000	3000
TLR	0	3	3	0	5700	5700
MATPI	0	2	2	0	950	950
NUCE	0	3	3	0	2300	2300
PEM	0	5	5	0	650	650
PHYCS	0	2	2	0	300	300
PSYCH	0	9	9	0	2500	2500
SOCW	0	1	1	0	1200	1200
TAM	0	5	5	0	2100	2100
VCM	0	1	1	0	800	800
VTED	0	1	1	0	600	600
ZOOL	0	1	1	0	2200	2200
SUBTOTAL	13	128	141	4900	58750	63650
DCSSYS[3]	0	36	36	0	15200	15200
XDCS[4]	0	1	1	0	100	100
TOTAL	13	165	178	4900	74050	78950

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Updating

IPM 1800 TABLE III SEPTEMBER 1969

SECONDS--1800 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGE	0	2	2	0	1736	1736
CE	0	4	4	0	6406	6406
EE	0	24	24	0	3172	3172
MATL	0	2	2	0	458	458
PHYSI	0	21	21	0	3250	3250
SUBTOTAL	0	53	53	0	15022	15022
DCSSYS[3]	0	78	78	0	54818	54818
REFUND[4]	0	3	3	0	2397	2397
XDCS[5]	0	1	1	0	69	69
TOTAL	0	135	135	0	72306	72306

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 System Updating

IBM 1800 TABLE III 3RD QTR 1969

SECONDS--1800 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGE	0	4	4	0	2427	2427
AGRON	0	26	26	0	18787	18787
ARCH	11	0	11	5949	0	5949
BIOPH	0	25	25	0	9205	9205
CE	0	11	11	0	30511	30511
COLCOM	0	12	12	0	6362	6362
CRC	0	11	11	0	8159	8159
CSL	0	6	6	0	785	785
DCS	0	1	1	0	5	5
EE	0	75	75	0	16047	16047
ET	0	1	1	0	621	621
MATRL	0	2	2	0	458	458
NUCE	0	20	20	0	36235	36235
PHYSL	0	21	21	0	3250	3250
VPP	0	4	4	0	5943	5943
SUBTOTAL	11	219	230	5949	138795	144744
DCSSYS[3][4]	0	384	384	0	153878	153878
REFUND[4]	0	18	18	0	5436	5436
XDCS[5]	0	1	1	0	69	69
TOTAL	11	622	633	5949	298178	304127

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 System Updating

IBM 360/20 TABLE III 3RD QTR 1969

MINUTES--360/20 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	38	18	56	240	280	520
ACCY	73	20	93	304	248	552
ADV	0	2	2	0	43	43
AGE	0	57	57	0	772	772
AGEC	19	147	166	459	1548	2007
AGRON	11	26	37	126	115	241
ANS	5	64	69	50	363	413
ARCH	1	0	1	8	0	8
ASTR	0	31	31	0	195	195
BADM	2	3	5	8	82	90
BECRSR	0	1	1	0	21	21
BINRES	0	8	8	0	129	129
CE	62	184	246	701	2503	3204
CERL	0	34	34	0	394	394
CEUSA	0	5	5	0	12	12
CHE	0	212	212	0	2544	2544
CLASS	0	44	44	0	337	337
CRC	0	44	44	0	837	837
CSL	0	44	44	0	434	434
CURLAB	0	1	1	0	40	40
DATLOG	0	1	1	0	2	2
DCS	221	186	507	1243	933	2176
DS	0	53	53	0	422	422
DSEA	0	2	2	0	51	51
ECON	0	14	14	0	224	224
ED	2	73	75	10	1201	1211
EDADM	0	1	1	0	13	13
EDPSY	15	0	15	100	0	100
EE	20	118	138	64	1036	1100
ENGADM	0	31	31	0	313	313
ENGCST	0	44	44	0	498	498
ENGH	6	0	6	27	0	27
ENTOM	0	18	18	0	43	43
FIN	11	36	47	135	315	450
FT	0	7	7	0	66	66
GENE	16	0	16	69	0	69
GEOG	0	2	2	0	45	45
GEOL	0	28	28	0	198	198
GSA	0	3	3	0	35	35
HEC	0	1	1	0	50	50
HED	0	84	84	0	4185	4185
HORT	0	21	21	0	111	111
ICR	0	65	65	0	829	829
ILLDME	0	5	5	0	173	173
ILR	0	19	19	0	206	206
INADM	0	7	7	0	89	89
LIBS	0	4	4	0	26	26
MATH	2	28	30	3	67	70
MATRL	0	239	239	0	2441	2441
MCRIC	0	2	2	0	8	8
ME	54	120	174	213	1014	1227
MKTG	0	7	7	0	73	73
MUSIC	40	12	52	239	82	321

NHS	0	4	4	0	5	5
NUCE	11	76	87	47	800	847
OIR	0	41	41	0	847	847
ORMF	0	1	1	0	50	50
PEM	0	53	53	0	630	630
PHYB	0	16	16	0	74	74
PHYCS	0	145	145	0	1236	1236
PHYSL	0	7	7	0	15	15
PHYX	0	52	52	0	713	713
POLS	0	20	20	0	174	174
PROVST	0	25	25	0	497	497
PSYCH	10	218	228	86	2831	2917
REC	1	27	28	39	686	725
SCONS	0	4	4	0	15	15
SGS	0	42	42	0	911	911
SOC	0	58	58	0	1786	1786
SOCW	0	15	15	0	177	177
SRL	5	12	17	77	166	243
SSUAD	0	1	1	0	5	5
SWS	0	25	25	0	136	136
TAM	5	67	72	14	350	364
UOSCR	0	27	27	0	488	488
USGS	0	1	1	0	2	2
VPH	0	10	10	0	134	134
VPP	0	4	4	0	34	34
VTED	0	34	34	0	635	635
ZOOL	0	7	7	0	266	266
SUBTOTAL	730	3168	3898	4362	39479	43841
CCSSYS[3]	0	767	767	0	7566	7566
REFUND[4]	0	10	10	0	145	145
UADP[5]	0	3	3	0	67	67
XDCS[6]	0	18	18	0	119	119
XMAINT[7]	0	898	898	0	39334	39334
TOTAL	730	4864	5594	4362	86710	91072

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 University Administrative Overhead Use
6 System Updating
7 System Maintenance

IBM 360/75 TABLE III 3RD QTR 1969

MINUTES--SERVICE PROGRAMMING

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGEC	0	3	3	0	270	270
CE	0	5	5	0	1260	1260
CHE	0	5	5	0	540	540
CRC	0	2	2	0	900	900
ED	0	4	4	0	2310	2310
ENTOM	0	1	1	0	360	360
FIN	0	2	2	0	1380	1380
ET	0	6	6	0	3360	3360
GEOG	0	6	6	0	1965	1965
MATRI	0	3	3	0	300	300
PSYCH	0	1	1	0	720	720
ZOOL	0	4	4	0	3060	3060
SUBTOTAL	0	42	42	0	16485	16485
TOTAL	0	42	42	0	16485	16485

1 See list of departmental codes following
2 Training and Education

SECONDS--360/75 REAL TIME
Sequential System

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAF	641	476	1117	30496	24511	55007
ACCY	1844	214	2058	39330	12268	51598
ADV	0	38	38	0	2160	2160
AGE	1	704	705	54	21862	21916
AGEC	267	1529	1796	12618	120519	133137
AGRON	155	426	581	3118	15452	18570
ANS	19	186	205	798	4688	5486
ARCH	297	0	297	13191	0	13191
ASTR	0	239	239	0	11982	11982
BADM	12	40	52	634	765	1450
BECBSP	0	40	40	0	3201	3201
BINRES	0	98	98	0	6125	6125
BIOPH	0	31	31	0	755	755
BOT	0	39	39	0	1203	1203
CDA	0	2	2	0	31	31
CE	2428	4094	6522	94561	137077	231638
CERL	0	119	119	0	5439	5439
CEUSA	0	86	86	0	5530	5530
CHE	11	3680	3691	2500	200444	202944
CIRCE	0	3	3	0	61	61
CLASS	0	2343	2343	0	93732	93732
COLCOM	0	14	14	0	291	291
CRC	0	305	305	0	17936	17936
CSL	0	421	421	0	23491	23491
DATLOG	0	4	4	0	95	95
DCS	7565	1600	9165	192240	115194	307434
DS	0	357	357	0	27541	27541
ECON	27	115	142	572	4336	4908
ED	162	505	667	5164	20601	25765
EDADM	0	88	88	0	7325	7325
EDPSY	308	11	319	4765	608	5373
EE	640	1775	2415	17899	96350	114249
ENGADM	0	611	611	0	45813	45813
ENGCST	0	646	646	0	41019	41019
ENGH	77	0	77	1876	0	1876
ENTOM	0	73	73	0	2204	2204
FIN	209	96	305	18110	4091	22201
FOR	0	34	34	0	735	735
FT	0	89	89	0	3310	3310
GENE	76	14	90	2444	267	2711
GEOG	0	41	41	0	2110	2110
GEOL	0	247	247	0	14025	14025
GSA	0	19	19	0	544	544
HEC	0	26	26	0	1262	1262
HED	0	115	115	0	28952	28952
HONORS	0	10	10	0	915	915
HORT	0	70	70	0	4143	4143
ICR	0	618	618	0	26522	26522
IE	31	0	31	575	0	575
ILLDMH	0	260	260	0	33091	33091
ILR	0	104	104	0	4008	4008
INADM	0	85	85	0	8043	8043
LIBS	0	49	49	0	2876	2876

MATH	29	296	325	4163	42266	46429
MATRL	0	3786	3786	0	241464	241464
MCBIO	0	104	104	0	3132	3132
MCCL	0	6	6	0	146	146
ME	362	1227	1589	42729	37809	80538
MILPOL	0	4	4	0	126	126
MKTG	0	63	63	0	2371	2371
MUSIC	500	36	536	31502	1364	32866
NHS	0	10	10	0	330	330
NUCE	133	742	875	3896	54756	58652
OTP	0	586	586	0	29564	29564
PERMF	0	5	5	0	75	75
PEM	0	244	244	0	10067	10067
PHYR	0	429	429	0	22706	22706
PHYCS	0	2121	2121	0	95302	95302
PHYSI	-1	173	172	-301	2905	2604
PHYX	0	536	536	0	105257	105257
POLS	15	305	320	479	16161	16640
PROVST	0	79	79	0	5621	5621
PSYCH	130	2232	2362	8337	136762	145119
REC	70	138	208	5572	10433	16005
SCENS	0	93	93	0	4540	4540
SGS	0	542	542	0	13033	13033
SOC	0	332	332	0	23833	23833
SPED	0	33	33	0	739	739
SPI	611	465	1076	33355	24206	57561
SWS	0	1941	1941	0	74133	74133
TAM	171	665	836	7303	37232	44535
UOSCP	0	124	124	0	14332	14332
USGS	0	22	22	0	454	454
VPH	0	29	29	0	713	713
VPP	0	94	94	0	1874	1874
VTED	0	177	177	0	11440	11440
ZOOL	0	309	309	0	14059	14059
SUBTOTAL	17490	41132	58622	578830	2281909	2860739
CCSSYS[3]	0	6843	6843	0	1153557	1153557
CVRHED[4]	0	23	23	0	394	394
REFUND[5]	0	941	941	0	251111	251111
UADP[6]	0	96	96	0	10294	10294
XDCS[7]	0	510	510	0	365340	365340
XMAINT[8]	0	76	76	0	240535	240535
XSSS[9]	0	1882	1882	0	59420	59420
TOTAL	17490	53408	70898	578830	4871560	5450390

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

IBM 360/75 TABLE III 3RD QTR 1969

CARDS KEYPUNCHED

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
ACCY	1	3	4	50	800	850
ADV	0	1	1	0	800	800
AGE	0	1	1	0	1000	1000
AGEC	0	13	13	0	9850	9850
ANS	2	5	7	1300	2900	4200
ASTR	0	5	5	0	5750	5750
CE	1	8	9	100	17750	17850
CHE	0	4	4	0	2600	2600
CLASS	0	2	2	0	3550	3550
CRC	0	232	232	0	37700	37700
DCS	6	37	43	1350	15400	16750
DSEA	0	1	1	0	2000	2000
ED	2	19	21	2000	7750	9750
EDADM	0	1	1	0	700	700
EDPSY	0	5	5	0	1000	1000
EE	0	16	16	0	6550	6550
ENGADM	0	1	1	0	600	600
ENGCST	0	3	3	0	4400	4400
FIN	4	4	8	1200	1400	2600
FOR	0	2	2	0	7800	7800
FT	0	7	7	0	1300	1300
GEOL	0	5	5	0	3500	3500
HEC	0	1	1	0	100	100
HORT	0	3	3	0	6600	6600
ILR	0	6	6	0	12700	12700
LIBS	0	2	2	0	1100	1100
MATRL	0	5	5	0	5900	5900
ME	0	1	1	0	250	250
MILPOL	0	1	1	0	200	200
MUSIC	3	0	3	2800	0	2800
NUCE	0	4	4	0	3000	3000
PEM	0	11	11	0	2950	2950
PHYCS	0	2	2	0	300	300
PHYX	0	8	8	0	6800	6800
POLS	1	2	3	200	1000	1200
PSYCH	0	20	20	0	11200	11200
REC	0	3	3	0	1100	1100
SOC	0	1	1	0	600	600
SOCW	0	1	1	0	1200	1200
SPED	0	1	1	0	600	600
SRL	0	2	2	0	4300	4300
TAM	0	6	6	0	2250	2250
USGS	0	1	1	0	200	200
VCM	0	4	4	0	3100	3100
VTED	0	4	4	0	1400	1400
ZOOL	0	1	1	0	2200	2200
SUBTOTAL	20	465	485	9000	204150	213150

CSSYS[3]	0	109	109	0	39600	39600
DCS[4]	0	1	1	0	100	100
OTAL	20	575	595	9000	243850	252850

[3] See list of departmental codes following
Training and Education
System Improvement and Modifications
System Updating

LIST OF DEPARTMENT CODES

The following list of codes are those codes for which the Department of Computer Science has on file one or more authorized signatures. If your department or office does not appear on this list, please write its full name in the department field on the Problem Specification Form even though it may require more than 6 characters.

AAE	Aero. and Astro. Eng.
ACCREC	Accounts Receivable
ACCY	Accountancy
ACTGDV	Accounting Division
ADV	Advertising
AFS	Air Force Science
AGE	Agricultural Eng.
AGEC	Agricultural Economics
AGED	Agricultural Ed.
AGREXT	Agricultural Extension
AGRON	Agronomy
ALUMNI	Alumni Assoc.
AMCDEC	Adolf Meyer Center Decatur Ill.
ANS	Animal Science
ANTH	Anthropology
ARCH	Architecture
ART	Art
ASTR	Astronomy
AUDIT	Auditing Division
AVI	Aviation
BADM	Business Admin.
BAND	Band
BCMPL	Bureau of Community Planning
BECBSR	Bureau of Econ. and Bus. Res.
BED	Business Ed.
BEDRES	Bureau of Ed. Res.
BINRES	Bureau of Institutional Res.
BIOPH	Biophysics
BOT	Botany
BURSAR	Bursar's Office
CE	Civil Eng.
CERE	Ceramic Eng.
CHE	Chemistry and Chemical Eng.
CICBIO	Comm. Inst. Coop. Bio. Grad. Prog.
CIRCE	Cen. for Instr. Res. and Curr. Ev.
CLASS	Classics
CMPTOL	Comptroller's Office
COMM	Communications
CP	City Planning
CPUBS	Champaign Public Schools
CRC	Children's Res. Center
CSL	Coordinated Science Lab.
CURLAB	Curriculum Lab.
CZR	Center for Zoonoses Res.
DANCE	Division of Dance
DCS	Dept. of Computer Science
DGS	Division of General Studies (LAS)
DNSTUD	Dean of Students
DNW	Dean of Women
DOW	Division of Waterways
DS	Dairy Science
DSFA	Dept. of Stud. Fin. Aid
DUE	Division of University Ext.
ECON	Economics
ED	College of Ed.
EDADM	Educational Admin. and Super.
EDPSY	Educational Psychology
EE	Electrical Eng.
ENGADM	Engineering Admin.
ENGCST	Engineering College and Station
ENGH	Engineering Honors Program
ENGLSH	English
ENTOM	Entomology
FIN	Finance
FOR	Forestry
FR	French
FT	Food Science
GENE	General Eng.
GEOG	Geography
GEOL	Geology
GER	Germanic Languages and Lit.
GRDCOL	Graduate College
GRK	Greek
GSA	Graduate Student Assoc.
HACDMH	Herman Adler Zone Center Champaign
HEC	Home Economics
HED	Health Ed.
HIST	History
HLTHSV	Health Services
HONORS	Honors Program
HORT	Horticulture
HOUDIV	Housing Division
HYG	Hygiene
ICR	Inst. of Communications Res.
IE	Industrial Eng.
IGPA	Inst. of Government and Public Affairs
ILLCF	Illini Christian Fellowship
ILLDMH	State of Ill. Dept. of Mental Health
ILR	Inst. of Labor and Industrial Rel.
INSTTV	Instructional TV
IREC	Inst. for Res. on Except. Children
ISEDAD	Ill. St. U. Dept. of Ed. Admin.
ITAL	Italian
JOURN	Journalism
LA	Landscape Architecture
LAS	Liberal Arts and Sciences
LAT	Latin
LAW	Law
LIBS	Library Science
LING	Linguistics
MATH	Mathematics
MATRL	Materials Res. Lab.
MCBIO	Microbiology
ME	Mechanical Eng.
MILS	Military Science
MKNLY	McKinley Hospital

PE	Min. Met. and Petr. Eng.
SIC	Music
S	Natural History Survey
	Naval Science
CE	Nuclear Eng.
C	Office of Agricultural Comm.
S	Office of Admin. Studies
R	Office of Instr. Resources
M	Phys. Ed. for Men and Grad PE
RRIF	Pershing Rifles
W	Phys. Ed. for Women
IL	Philosophy
YB	Physics Betatron Lab.
YCS	Physics
YPLA	Physical Plant
YSL	Physiology
YX	Physics Project X
PA	Plant Pathology
LS	Political Science
RT	Portuguese
OVST	Provost's Office
DEC	Spec. Ed. Decatur Public Schools
YCH	Psychology
YTR	Psychiatry
R	Purchasing Division
C	Recreation
ET	Rhetoric
OC	Rural Sociology
V	Radio and Television
SHIS	Russian and area Studies
ONS	Soil Conservation Service
S	Student Counseling Service
S	State Geological Survey
CBRC	Small Homes Council
AV	Slavic Languages and Lit.
C	Sociology
CW	Social Work
LS	School of Life Sciences
AN	Spanish
CH	Speech and Theatre
ED	Special Ed.
L	Survey Research Lab.
S	State Water Survey
M	Theoretical and Applied Mechanics
DP	Univ. Admin. Data Processing
CTE	U-C Council on Teacher Ed.
IHI	Univ. High School
SCR	Univ. Off. of School and Coll. Rel.
PLAN	Urban Planning
GS	U. S. Geological Survey
H	Vet. Anatomy and Histology
M	Vet. Clinical Medicine
S	Vet. Medical Science
H	Vet. Path. and Hygiene
P	Vet. Phys. and Pharm.
ED	Vocational Ed.
GU	WPGU Radio Station
OL	Zoology

Chicago Circle

CCARCH	Architecture
CCCHE	Chemistry
CCDME	Materials Engineering
CCENEN	Energy Engineering
CCGEOL	Geology
CCPHCS	Physics
CCPSYC	Psychology
CCSCS	Stud. Counsel. Service
CCSOC	Sociology

Chicago Medical Center

MCCL	Med. Cen. Comp. Lab.
ORME	Off. of Res. in Med. Ed.
OT	Occupational Therapy

Ill. State University, Normal

ISEDAD	Dept. of Ed. Admin.

Western Ill., Macomb

WIULAB	West. Ill. Univ. Lab School

10.2 Research Problem Specifications

During the third quarter of 1969,243 problem specifications were submitted to the Department for computation on the System/360. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

2673 Civil Engineering. Dynamic Response of Multi-story Buildings. Nonlinear behavior of multi-story buildings subjected to ground motion. Study of the effect of the hysterisis curve (Elasto - plastic; Ramberg-Osgood - elastic) on the response. (N. Nielsen)

2674 T Education. Bolivian Teaching Methods and Organizational Climate. Bolivian teaching methods and organizational climate. (L. McCleary)

2675 Materials Research Lab. Thallic Oxide Structure. Bonding parameters and orbital overlap in the thallic oxide structure are to be analyzed to explain the observed metallic conductivity in the oxide. (G. Wirtz)

2676 T Advertising. Perceived Risk and Personality. Analysis of variance and correlations to determine relationships between products, personalities and advertising preference. (J. Hadley)

2678 T Zoology. The Effects of Haemonchus contortus on the Erythropoietic System of Lambs. The reasons for this study are to more clearly define the type of anemia associated with haemonchosis and to show that oral iron given ad. lib. to lambs infected with Haemonchus contortus L_3 larvae might be an aid in the alleviation of the haemonchosis syndrome. (R. Weise)

2679 T Chemistry. NMR Kinetic Studies. Rates of exchange will be determined by comparing a series of experimental NMR spectra at different degrees of coalesence with calculated spectra for a best fit. (R. Basalay)

2680 Natural History Survey. Manipulation of Roadside Cover for Nesting Pheasants. An evaluation of the potential of managing roadside cover for nesting pheasants in intensively-farmed east-central Illinois. (G. Joselyn)

2681 Physics Betatron Laboratory. Nuclear Parameter Measurements. Measurement of the (γ , γ) and (γ ,n) cross sections of Pb^{208}, Pb^{206}, Zr^{90}. (P. Axel)

2682 Veterinary Physiology and Pharmacology. Hypothalamic Control of the Avian Pituitary Gland. The problem is concerned with the mechanisms by which the hypothalamus controls the anterior pituitary in birds. It involves isolation and identification of substances produced in the hypothalamus, and an investigation of their physiological functions. The computer will be used to process results of assays of the biological activity of these substances, and to perform statistical tests.

2683 T Theoretical and Applied Mechanics. Finite Element Analysis of Shrinkage in Reinforced Concrete. Simultaneous solution of equilibrium and compatibility equations obtained from the stiffness matrix of one model. Results are displacement, loads, stresses. (H. Rejali)

2684 Electrical Engineering. Inverse Diffraction Transformation. Application of the Diffraction Transform to problems of inverse scattering. (Raj Mittra)

2685 Theoretical and Applied Mechanics. Dynamic Response of Springs. Analytical study of the static and dynamic behavior of helical springs. (G. Costello)

2686 T Physical Education for Men. Evaluation of Certain Aspects of PE doctorates. This replaces 7094 problem specification number 93002. (D. Fallon)

2688 T Psychology. Attention, Rules, and Conceptual Shifts. Children 4, 6, and 8 years of age were trained on a simple visual discrimination task and then required to solve a reversal shift. On each trial (for half the Ss) or every third trial (the other half) the child was asked to answer a question about his hypotheses about the task (Which ones are winners? or Which ones are losers?). Other variables manipulated were attention (to relevant or irrelevant dimension or neither) and reinforcement schedule instructions (continuous or probabilistic). Data of interest are prediction of choice responses from rule-statements (single-trial prediction and n-trial prediction) and the % of variance in rule-statements and choice responses accounted for. (R. Jeanene Pratt)

2689 Aeronautical and Astronautical Engineering. Skin-Stiffener Panels. Analytical study of free and forced vibrations of two dimensional multi-span panels. (Y. K. Lin)

2690 T Department of Computer Science. Synthesis of Digital Networks Consisting of NOR, OR, and NOR-OR Gates. Optimal logic networks consisting of OR, NOR and NOR-OR gate will be synthesized by using integer programming. The synthesis will be done for both single and double rail logic. Optimal networks will be obtained for all switching functions of three variables. (Sekar Chandersekaran)

2691 T Electrical Engineering. Logic System Failure Mode Analysis. Failure mode analysis of a single input-single output logic system designed to recognize a unique series of input bits. (P. Gilpin)

2692 Agricultural Economics. Experimental Farm Record Processing. Time to be used for testing new procedure for summarizing farm records data for an improved business analysis. (D. F. Wilken)

2693 Psychology. Factors Affecting Oddity Problem Solving in Children. Transfer performance in children's oddity learning as a function of dimensional preference and overtraining. (A. L. Brown)

2694 Curriculum Laboratory. Extending Visual Skills. Analysis of data gathered for curriculum lab of pre- and post-tests of the visual ability of third graders. (C. Rusch)

2695 T Chemistry and Chemical Engineering. Hypochromism by Simpson's Rule. Ultraviolet spectra of dinucleotide analogues. Digitizing spectra to calculate hypochromism. (T. Scott)

2696 Psychology. Evaluating Cognitive and Affective Outcomes of Teaching Psychology. 1-Personality correlates of teaching and learning: relationship between (a) teacher characteristics and course outcomes in psychology; (b) student characteristics and course outcomes. 2-Relationship between types of instructional aids in TV teaching and student learning and attitudes. Above problems involve construction of appropriate evaluation instruments and experimental procedures. (F. Costin)

2697 T Theoretical and Applied Mechanics. A Field Method for Numerical Integration. Numerical methods will be applied to the mechanics of deformable bodies for the determination of stresses, strains, and displacements. (S. A. Kiger)

2698 T Chemistry and Chemical Engineering. Non-Linear Wave Motions. Numerical integration of wave equations with initial boundary values. (Y. Kim)

2700 Mathematics. Sequential Design Time Series Confidence Bounds. Computational support for Bohrer's research under NSF Contract GP 8727 (see research proposal for details). (R. Bohrer)

2701 T Chemistry and Chemical Engineering. Reaction Rates in Critical Solutions. The computer is required to calculate thermodynamic properties near a second-order phase transition and the effects of molecular fluctuations on chemical kinetics in solution. (C. A. Eckert)

2702 Zoology. Oogenesis in Drosophila. A study of the effects of ovary size (number of egg tubes) on egg size and rate of egg production in the fruit fly, Drosophila melanogaster. (E. Brown)

2703 Civil Engineering. Expedient Lime Soil Stabl. Statistical analysis of laboratory data. (C. Neubauer)

2704 Astronomy. Photometric Reductions. Computer reduction of raw photometric data for eclipsing binary stars. (E. Olson)

2705 Theoretical and Applied Mechanics. Blood Flow Prosthetic Interface Study. This study will involve use of numerical methods for solution of the Navier-Stokes equations applied to blood flow around bends and over obstacles in order to correlate blood trauma and clotting procedures with fluid mechanic parameters. (M. E. Clark)

2706 T College of Education. The Modification of Dimensional Pre-Potency through Perceptual Pre-Training. K and 1st grade children presented with a learning task. Half the group of subjects given perceptual pre-training, half group of subjects given no pre-training. An analysis of the results of data obtained. (S. Goldberg)

2707 Animal Science. Gilt Breeding Study. This replaces problem specification (7094) number 94015. (D. H. Baker)

2708 T Electrical Engineering. Optimal-Formulation-Scattering. Numerical solution of specific scattering problem by means of optimal techniques. (S. Daniel)

2709 Animal Science. Composition of Mice. This replaces problem specification (7094) number 48032. (H. W. Norton)

2710 T Chemistry and Chemical Engineering. Orr-Sommerfeld Equation. Solution of the Orr-Sommerfeld equation using the method of Kaplan. (G. Cook)

2711 T Electrical Engineering. Automatic Parameter Adjustment. A case study of parameter variation effects in a Control System design problem. (J. Garcia)

2713 College of Education. O. C. I. - Occupational Characteristics Index. Continuing analysis of responses of various groups to the items contained in the Occupational Characteristics Index. Analyses will be used for research into behavior of professional personnel and for the validating of the instrument. (T. L. McGreal)

2714 Sociology. Police Processing of Juveniles. Multivariate analysis will be performed on official Police Statistics on Juvenile Delinquents for the cities of Detroit and Chicago. Emphasis in the analysis will be upon isolations of Delinquent Referral Patterns by Police. (D. J. Bordua)

2715 Psychology. Clinical Program Evaluation. Factor analysis of ratings of students by faculty. Correlations between various other behavioral measures from students and faculty. (D. Peterson)

2716 Mechanical Engineering. Imperfect Modeling. Computer research on thermal modeling of spacerafts. (B. Chao)

2717 Animal Science. Growth Study of Swine Lens Nitrogen. This replaces problem specification (7094) number 95003. (R. G. Kauffman)

2718 Animal Science. Sensitivity to Cortisone as a Genetic Character of Mice. This replaces problem specification (7094) number 94014. (B. M. Francis)

2719 Provost's Office. Follow-up Research about Transfer Students. Transfer student data will be summarized and analyses made to determine factors related to success. (E. F. Anderson)

2720 T Economics. Incidence of Indirect Taxes. A general equilibrium model that measures the incidence of indirect business taxes. (C. Carlson)

2721 Agricultural Economics. Incentives and Human Resource Development. Routine data manipulation, including index construction, bivariate and multi-variate statistical analyses. (F. C. Fliegel)

2722 T Physical Education for Men. Effects of Intramural Basketball Competition on the Group Cohesiveness Level. This replaces problem specification (7094) number 95013. (J. Peterson)

2723 Chemistry and Chemical Engineering. P. Chem. Lab. Computations will be made in connection with developing undergraduate P. Chem. Lab experiments which will interact with a computer. (D. Secrest)

2724 T College of Education. Vocational Interest of Children. Analysis of vocational interests of children. Utilization of Havighurst's developmental task for preference indication. (C. Burden)

2725 Astronomy. Stellar Luminosities. Digitized microphotometer data for stellar spectrograms will be processed in the computer, yielding luminosities, which in turn permit the derivation of stellar distances. (K. Yoss)

2726 Library Science. Public Library Government, Organization and Support. The objectives of this study are to study the various aspects of the operation and control of public libraries in the United States. (C. Kronus)

2727 Animal Science. Swine Breeding and Selection. A swine breeding and selection project is producing data on the rate of progress under selection for total body potassium. These data will be summarized and analyzed to estimate rate of selective progress, its heritability, and its genetic correlation with other items such as backfat thickness and litter size. (H. W. Norton)

2728 Vocational and Technical Education. Career Patterns. Staff research activity to further analyze data previously collected on a funded project. (R. Tomlinson)

2729 College of Education. Class Preference as a Function of Conceptual Level and Instructional Style. Research involves determining patterns of student class preference and performance as a function of student personality matched with style and content of class instruction. (M. L. Maehr)

2731 T Physical Education for Men. Effects of Training on Stress Indicators. Training will continue for 16 weeks. Subjects train at different intensities. Data will be analyzed at T_1-before training, T_2 8 weeks of training and T_3 end of training. Variables measured will be 13 blood parameters, ketosteroids, cardiac intervals and oxygen intake. Data analyzed by analysis of variance. (J. Misner)

2732 T Physical Education for Men. The Relationship between the ITPA and Selected Perceptual-Motor Abilities in Kindergarten Children. The relationship between the Illinois Test of Psycholinguistic Abilities; Selected perceptual-motor abilities; performance on the Rod and Frame; and performance on the Metropolitan Readiness Test was tested in kindergarten children and an analysis of the results was made through the use of Varimax factor analysis, product-moment correlation and t-tests. (B. Fish)

2733 T College of Education. Negotiability among Teachers Union. Determining difference in perception of negotiability of items among teachers, union delegates, and principals in selected schools in Illinois. (T. Plain)

2734 T Physics. Glauber Calculations. The compositness of elementary particles is studied by analyzing multiple scattering of constitutients in collisions of the composite particles. (W. C. Thacker)

2735 Children's Research Center. Analysis of Physiological, Behavioral and Subjective Measures as a Function of Stress. Analysis is to be made of the effects of enhanced autonomic nervous system feedback on physiological, behavioral, and subjective measures as a function of film-induced stress. (F. Fehr)

2736 Children's Research Center. Behavioral Analysis of Emotionally Disturbed Children. Emotionally disturbed children are observed in an elementary classroom setting. Data will be gathered on the frequency of deviant behavior and on performance in various experimental situations. Computer time will be used to statistically analyze the data gathered. (M. Gold)

2737 Children's Research Center. The Development of Language in Children. Study is to be made of phonologic development in children and of the impact of subvocal speech on language development. Analyses will be made of data gathered in experiments studying various aspects of language development. (J. Locke)

2738 Children's Research Center. Language Development in Children. A comparison is to be made of selected measures with psychological scale values of language development. Four linear multiple-regression analyses will be used to determine the best composite for predicting scale values of language development derived from children of four different age categories. (T. Shriner)

2739 Children's Research Center. The Analysis of Behavior in Hyperactive and Aggressive Children. Study will be made of the effects of methylphenidate, phenobarbital and placebo on the behavior of hyperactive and aggressive children. A direct frequency count technique will be used to assess the psychopharmacological effects of these drugs on behavior in a classroom setting.

2740 Engineering College and Station. Earthquake Analysis. The analysis of response of a building to strong ground motion. (M. Sozen)

2741 T Political Science. Ethnic Racial Attitudes. Analysis of survey data - questions on ethnic attitudes toward Negroes. (T. Pavlak)

2742 Geography. Evaluation of Physical Geography 103. Evaluation of student and teaching assistant reactions to Geography 103. (J. Monk)

2743 Civil Engineering. Transmitting Boundary. A series of problems will be run to test the feasibility of a new type of boundary condition for problems in continuum mechanics. (L. Lopez)

2744 Civil Engineering. SDF Systems. Response spectra will be obtained for a number of SDF systems. (L. Lopez)

2745 T Educational Administration and Supervision. The Effect of Family Living Programs in the Intermediate Grades. A pre-test, post-test analysis of the effects of a new "Family Living" (Sex Education) Program on 4th, 5th and 6th grade pupils, parents, and staff, as measured on Osgood's Semantic Differential. (T. Kolesnik)

2746 Sociology. Attitude Formation Research. This research involves the calculation of the relative amounts of influence over the attitudes of an individual exercised by significant others, self-reflexive acts and related cognitive structures. (J. Woelfel)

2747 Social Work. Mental Health Community Study. Mental patient movements, interviews, and questionnaire data from two Illinois counties are being compared, 1965-69, to determine the impact of a new mental health program. (M. Taber)

2748 T College of Education. Student Surveys in Ed. Psych. Departmental Research. (S. Jones)

2749 College of Education. Teaching Research. Analysis of data generated in teaching experiences laboratory. (W. Johnson)

2751 Nuclear Engineering. Particle Dispersion: Turbulence. Statistical analysis of particle trajectory data and fluid turbulence. Research is related to water pollution and fundamental turbulence. (B. Jones)

2752 T College of Education. College Success Factors. This study will attempt to measure the effect of various factors (size of high school, wealth of high school, participation in activities by students, etc.) on success in college. (R. Brown)

2753 T Psychology. Varying Reinforced and Varying Selected Cues. Five factor Anovar: 2 within (fixed); 3 between (random). 199 subjects. (S. Smiley)

2754 T Chemistry and Chemical Engineering. Properties of Roll Waves. The profiles of Roll waves can be obtained numerically by using Runge-Kutta scheme. (M. Miya)

2755 Forestry. Forest Tree Improvement Studies. Genetic studies of forest tree species and their improvement through selection and breeding. (J. Jokela)

2756 Astronomy. Stellar Motions. The component of stellar motions perpendicular to the galactic plane will be studied as a function of luminosity, temperature, and composition of the stars involved. Stars near the north galatic pole will be used so that their radial velocities will approximate the perpendicular component of the motion. (E. Avner)

2757 Civil Engineering. Soil Classification. Prepare an engineering soils manual for the State of Illinois. (T. Thornburn)

2758 Survey Research Laboratory. 039 - Tabulations. Tabulating data for Study 039. (R. Ferber)

2759 Survey Research Laboratory. 041 - Tabulations. Tabulating data for Study 041. (R. Ferber)

2760 Survey Research Laboratory. 041 - Cleaning Runs. Cleaning data for Study 041. (R. Ferber)

2761 Survey Research Laboratory. 039 - Cleaning Runs. Study 039 Cleaning Runs. (R. Ferber)

2762 T Psychology. Some Aspects of Reciprocity. An investigation of reciprocating behavior, attitudes and behavior intentions in a dyadic exchange situation. (E. Thomanek)

2763 Chemistry and Chemical Engineering. Vibrational Energy Transfer. This project will be used to calculate vibrational energy transfer times, using models which have been developed. The calculations will be used to compare to experimental results. (J. Yardley)

2764 T Chemistry and Chemical Engineering. Turbulence. Numerical integration of Laplace transformations. (G. Fortuna)

2765 Institute of Labor and Industrial Relations. Public Employee Unionism. Regression analysis of wages and other variables. (P. Hartm

2766 T College of Education. Federal Aid. A study of the use of Federal aid to prepare personnel for the handicapped. (C. Horn)

2767 T College of Education. Thesis Research. Departmental Thesis Research. (T. Manolakes)

2768 Economics. Economics Educational Research. Various hypotheses about the teaching of economics in high schools and colleges will be tested by regression analysis techniques. (E. Moyer)

2769 State Water Survey. Rain Field Drop Studies. Measurements of an artificial rain field will be analyzed. (E. Mueller)

2770 T Health Education. Knowledge Test of Traffic Laws. This project is concerned with the development of a knowledge test of traffic laws and regulations for high school driver education students. (A. Rabe)

2771 State Water Survey. Variability of Drop Size. The variability of raindrop size distributions will be studied and related to measurements of an artificial rain field used for test purposes. (A. Sims)

2772 Theoretical and Applied Mechanics. Large Deflection of Plates. Large deflection of clamped plates by Ritz energy method. (W. Worley)

2773 Engineering Administration. University-Industry Communications Study. An investigation of communications between a university and industry with specific applications to the College of Engineering at the University of Illinois. (S. Allen)

2774 Natural History Survey. Studies in Pheasant Physiology. Investigating physiological parameters, mineral status, and pesticide levels in pheasants, taking into consideration sex, age, season, activity, and geographical region. (W. Anderson)

2775 Survey Research Laboratory. Study 046 Tabulations. SOUPAC tabulations on 'U of I, 1984' study. (R. Ferber)

2776 Survey Research Laboratory. Non-Chargeable Programming. Program development and testing. (R. Ferber)

2777 Survey Research Laboratory. Study 043. Data manipulation for mini-omnibus study. (R. Ferber)

2778 Survery Research Laboratory. Study 230 Cleaning. Cleaning data for consumer panel study. (R. Ferber)

2779 Survey Research Laboratory. Study 046 Cleaning. Cleaning data for 'U of I, 1984' study. (R. Ferber)

2780 Survey Research Laboratory. Study 230 Tabulations. SOUPAC tabulations on consumer panel study. (R. Ferber)

2782 Home Economics. Change of Infant State. This study examines the impact of kinesthetic stimulation upon infant activity level and mood. The statistical design calls for an analysis of covariance with age and sex as independent variables and other selected factors as covariates, including the infant's developmental quotient, his sibling position, and frequency of parental rocking. (L. Vandendaele)

2783 Psychology. Expectancy. Analysis of the relationships among payoff contingencies, expectancies, performance feedback and role performance within complex interdependent situations. Quantitative analyses include complex correlational and mean difference procedures. (G. Graen)

2785 State Water Survey. Remote Terminal Account. This number is being setup to handle the 2780 Remote Terminal Accounting and Material charges. (R. Sinclair)

2786 College of Education. Counselor Education Follow Up Study. Evaluation of questionnaire data gathered on 300 graduates of advanced degree programs in Counselor Education (Educational Psychology). Included in the study are demographic, course and program evaluations, and career development variables. (D. Delaney)

2787 Social Work. Clinical Social Attitudes. Analysis of change in social work student orientations to social work, under different educational programs, on different campuses. (M. Taber)

2788 T Psychology. Propositional Learning. Statistical analysis of verbal learning data. (R. Hart)

2789 Civil Engineering. Latticed Structures. Analysis of latticed hyperbolic paraboloid in order to establish relations between latticed and continuum shells. (B. Mohraz)

2790 Civil Engineering. Elastoplastic Tunnel. Analytical study of behavior of tunnels in rock to correlate with behavior observed in model tests and full scale prototype structures. (A. Hendron)

2792 Dairy Science. Long Time Urea. To determine the effects of continuous feeding of 2 levels of urea vs. no urea from 12 weeks of age through 3 lactations in dairy cattle. (J. Clark)

2793 Physical Education for Men. Comparison of Women's Throwing Patterns. To examine differences among different skill groups. Statistical analyses required: Trend analysis: Anova - Scheffe's multiple comparison; Correlations - Pearson Product Movement. Transfer from 7094 problem specification number 94016. (H. Deutsch)

2795 T Economics. Analysis of Neighborhood Movement. Statistical analysis of neighborhood movement in Decatur, Illinois. SOUPAC will be used. (J. Linne)

2797 Mechanical Engineering. Consulting. The project involves the optimization of a class of heat exchangers and regenerators. (C. Pedersen)

2799 T Agricultural Economics. Farm Business Adjustment. Combine the planning techniques of single period linear programming models and sequential cash-flow projections, including household-farm business relationships, in an operational procedure. Develop and test a procedure for using these planning models with farm families by Extension Service personnel. (D. Erickson)

2800 T Physical Education for Men. Training Effect on O_2 Intake. The purpose of the study is to determine the rectilinear relationship between maximal oxygen consumption and performance on the treadmill. Correlation procedures, step-wise prediction, and analysis of variance will be used. (N. Liu)

2801 Agronomy. C and MS Research 36-C and MS-70(W). Program development for C and MS Inspection and Marketing Problems. (M. Swanson)

2802 Computer-Based Education Research Laboratory. Meaningful Learning. Problems in the measurement and facilitation of the learning and remembering of connected discourse. (R. Anderson)

2803 Astronomy. Jovian Models. Compute the Stokes parameters for the synchrotron radiation from Jupiter for different size belts and different orientations. (J. Dickel)

2804 Animal Science. Amino Acid Nutrition in Chicks. Determination of available amino acids in intact proteins. (H. Scott)

2805 T Psychology. Social Stimuli Effects. Study of the effects of social stimuli on the performance and satisfaction of paranoid schizophrenics, nonparanoid schizophrenics and normals. (T. Owen)

2806 Psychology. Relation of Multiple Cue Learning. The problem will be an analysis of two independent variables and one dependent variable with respect to multiple cue learning. (E. Schenck)

2807 Chemistry and Chemical Engineering. Structure Analysis by X-ray Method. X-ray structure analysis of some molecules with biological importance. (I. Paul)

2808 Chemistry and Chemical Engineering. X-ray Structure Analysis. X-ray structure analysis of a number of compounds of organic or biological significance. (I. Paul)

2810 Psychology. Humans Are Animals. Investigates effect of animal learning variables, such as extinction and reinforcement delay, on human verbal learning. (T. Nelson)

2811 T Psychology. Pers. Correlates of Learning. SOUPAC programs for partial correlation matrix (15 by 15), analysis of covariance, and multiple regression for evaluation of M.A. thesis data. (J. Sipich)

2812 T Psychology. Small Group Problem Solving. Group and individual problem solving under varying situational conditions. (S. Shiflett)

2813 Animal Science. Forage Evaluation with Sheep. Sheep are being used in digestion and performance studies to evaluate experimental forages and develop laboratory methods for evaluating forage quality. (F. Hinds)

2814 Materials Research Laboratory. Solid State Physics. Model defect calculations and energy band calculations. (R. Maurer)

2817 T Physical Education for Men and Graduate Physical Education. Climbing Skills of Five-Year Olds. A study of climbing skills of five year old children. A development of norms and a controlled investigation of climbing skill improvement. (W. Hottinger)

2818 Materials Research Laboratory. Spinodal Decomposition. The problem is to obtain solutions to various second order equations that represent regular, ternary system stability limits, kinetic amplification factors and decomposition directions. Various three-component systems will be simulated in this manner. (J. Morral)

2819 Psychology. Child Research. Analyses of data from research projects dealing with children's learning and problem solving. (M. Weir)

2820 Psychology. Child Personality Antecedents. Multivariate investigation of the family attitude and child rearing practice antecedents of child personality factors at ages 6-8 years. (T. Dielman)

2821 Finance. Insurance Company Growth. Study of factors contributing to the 1954-1966 asset growth of four size categories of stock and mutual insurance companies. (S. Forbes)

2822 College of Education. Present Program for Disadvantaged Children. Analysis of test scores of disadvantaged children who received educational intervention. (M. Karnes)

2823 Psychology. A Comparasion of Regular and Special (SEOP) Psychology Courses. Predictor variables and outcome variables will be intercorrelated within regular Psychology 100 and Psychology 105 students. Also SEOP and regular classes will be compared on all variables, predictor and outcome. Analyses will be both on 1968-69 data, and for the 1969-70 classes. The 1969-70 study is supported by University of Illinois Research Board. (R. Menges)

2824 T Physical Education for Men and Graduate Physical Education. Influence of Induced Muscular Tension on Time Estimation. An investigation of the influence of induced muscular tension, produced by gripping a dynamometer, on a time estimation motor task. A SxT design with each S tested under 4 experimental conditions. Also involves a test of the inverted U function as based on Malmo's arousal theory. (N. Parker)

2825 T Political Science. Groups and Public Policy. The project involves an analysis of public attitudes toward intervention in Indochina during the period 1952-1955, particularly as these attitudes relate to other attitudes on domestic and foreign policy, and to standard SES variables. This bloc of computer time will be used primarily to do some final work involving factor and regression analyses, using the SOUPAC programs. (S. Welch)

2826 T Civil Engineering. Rail Stress Investigation. This investigation involves the determination of rail stresses due to wheel-rail contact. (G. Martin)

2828 T Materials Research Laboratory. Diffusivity of Hydrogen. Calculation of quantum diffusivity of hydrogen in metals to correlate with experiment. (C. Baker)

2831 Nuclear Engineering. Shielding by Ribbed Slabs. Simple, approximate methods will be devised to calculate the penetration of gamma radiation through ribbed slabs. These methods will be checked against "exact" methods of computation until it is determined that the simplified mathematical model is adequate. (H. Chilton)

2833 T Physical Education for Men and Graduate Physical Education. Achievement Orientation and Structure. An investigation of the effects of reinforced achievement orientation on the structure of the small group made up of the students in a physical education class. (G. McKelvey)

2834 T Advertising. Educational Television Survey. Survey on attitudes toward educational television. (H. Shoemack)

2835 Millikin University Political Science Department. Study of Undergraduate Political Science in Illinois. Study of Undergraduate Political Science in Illinois; involves questionnaires sent to department chairmen of the four-year colleges in the state. The study will attempt to draw conclusions, with special emphasis on the beginning course in political science offered by each institution. (S. Shull)

2836 T Biophysics. Biophysics Training. General graduate student use - Biophysical Research Problems. (C. Sybesma)

2837 T Psychology. Drugs and Schizophrenia. Controlled investigation of the withdrawal of maintenance tranquilizers in chronic schizophrenic mental patients. The withdrawal group is put on placebo and compared to two matched control groups. Each group (drug or placebo) is subdivided into learning or mileu therapy groups. (L. Tobias)

2838 Agricultural Engineering. Analysis of Rigid Frames. The project under which this problem falls has the title "Improved Analysis and Design of Farm Buildings". (J. Curtis)

2839 T College of Education. Long Division Study. A comparison of two ways of teaching the long division algorithm to fourth graders. (C. Dilley)

2844 Agronomy. Agronomy Statistical Laboratory. Statistical analysis of Agronomic research data. (S. Carmer)

2847 Survey Research Laboratory. Study 031 Cleaning. Cleaning data for dental patients study. (R. Ferber)

2848 Survey Research Laboratory. Study 031 Tabulations. Tabulations for dental patients study. (R. Ferber)

2849 Electrical Engineering. Tidal Effects in the Atmosphere. I intend to investigate tidal motions in the atmosphere under various influences. (M. Geller)

2850 Accountancy. Elementary Accounting Course. Investigation to determine whether elementary accounting courses should be taught at the freshman or sophomore level. (J. McKeown)

2851 Vocational Education. REDL. Rural urban educational development laboratory. (L. Phipps)

2852 T Botany. Kinetics of Oxygen Evolution. Fitting curves of a new model to experimental data concerning oxygen evolution. (R. Govindjee)

2854 T Psychology. Group Therapy Versus Bibliotherapy. To determine the relationship between various predictor and dependent variables in the treatment of obseity; specifically to compare the effectiveness of group therapy and therapy via written materials. (R. Hagen)

2856 T Botany. Oxygen Kinetics. Fitting curves to a new model from experimental data concerning oxygen kinetics. (M. West)

2857 T Physical Education for Men and Graduate Physical Education. Role Expectations. Comparison of role expectations of women physical education teachers and chairmen and relationship to satisfaction. (S. Wood)

2858 Mechanical Engineering. Air Breathing Propulsion Systems. Research in the area of air breathing propulsion systems. (W. Chow)

2859 T Botany. Oxygen Kinetics. Fitting curves to a new model using experimental data concerning oxygen kinetics. (R. Govindjee)

2860 Center for Instructional Research and Curriculum Evaluation. Evaluating the Illinois Gifted Programs. Educational evaluation. (E. House)

2862 T Psychology. Directional Fractionation. Analyses of variance will be used to investigate the effects on heart rate, skin conductance and finger volume of type of task, two level of stress, two sets of instructions, order of instructions, and intensity of a flashing light. (B. Blaylock)

2865 Geography. Movement and Migration. The purpose of the research is to assess the impact of various types of everyday movement (journey-to-work, shopping trips, etc.) upon migration behavior of households. It will employ various statistical and mathematical techniques to examine relationships within two sets of data. (C. Roseman)

2866 Library Science. Library Research Analysis. Investigation and statistical analysis of various aspects of library organization and operation. (T. Crowley)

2867 T Economics. Study of Consumer Asset Preferences. Analysis of consumer asset holdings via correlations among assets and regression of assets on consumer characteristics. (J. O'Brien)

2869 University of Illinois Commercial. Consulting. Thermal system studies. (W. Stoecker)

2870 Army Corps of Engineers. Construction Research Problem. The civilian and military construction industry is plagued with many problems. Current research methods such as the application of the Systems Approach will be used to provide timely and effective solutions. (J. Wright)

2871 Mechanical Engineering. Radiant Heat Transfer in Space. Studies are being conducted to develop improved analytical techniques for predicting heat transfer and temperature of surfaces in a space environment. (R. Hering)

2872 Psychology. Perceptual Constancy. Traditional notions about how perceptual constancy is accomplished by the perceiver is challenged by a number of simple perceptual models. This project continues work showing that constancy performance is not a static consequent of perceiver characteristics or of types of stimuli but rather depends upon the relative amounts of response-relevant stimulus variation existing in inputs. (H. Hake)

2873 T Physical Education for Men and Graduate Physical Education. Physical Fitness of Adult Women. The effects of a home exercise program of bench stepping and stair climbing on the physical fitness of adult women. (R. Pohndorf)

2875 T Nuclear Engineering. Multidimensional Transport. Solution of the multidimensional integral neutron transport equation by self-consistant semidirect variational techniques. (H. Stoll)

2876 Civil Engineering. Highway Welded Structures. Research project deals with behavior of welded highway structures. Project includes fatigue testing and photoelastic investigations and computer analysis. (C. Thrasher)

2877 Civil Engineering. US NSF GK 1894. Model effects upon theoretical and experimental results of the yield criterion. (J. Barry)

2878 T Civil Engineering. Surface Friction in Rock. To study the effects of surface roughness and moisture on the sliding friction of rock. (J. Coulson)

2879 T Agricultural Economics. Fertilizer Demand in Corn Belt. The project is an estimation of the demand function of fertilizer for the years 1945 through 1968. Emphasis is placed on the effects of the feed grain program since 1961 on fertilizer consumption. (A. Grommet)

2880 Psychology. Expectancy, Reward, and Job Satisfaction. Contribution of level of reward and difference from expectation to job satisfaction. (D. Ilgen)

2881 Psychology. Reinforcement versus Milieu Therapy. Reinforcement versus milieu therapy. (P. Olson)

2882 Chemistry and Chemical Engineering. 2780 Terminal Service. General number to use in Terminal (2780) checkout. (D. Secrest)

2885 T Nuclear Engineering. Neutron Pulse Propagation. The study of time, energy and space dependent neutron spectra in a polycrystalline material after the introduction of fast neutrons via a pulse source. (K. Ibrahim)

2886 T Speech and Theatre. Stage Fright. This is a factor analytic study of the dimensions of anticipated communicative anxiety. Through oblique and orthogonal rotation procedures, the variables related to anxiety in communicative situations will be established. (W. Page)

2892 Agricultural Engineering. Analysis of Repair Cost Data. Analysis of machinery repair cost data. (D. Hunt)

2893 State Geological Survey. Carbonate Rock - SO_2 Sorption. Study of petrographic and mineralogical characteristics of carbonate rocks related to sulfur oxide sorption in flue gases. (R. Harvey)

2899 Materials Research Laboratory. Data Analysis. Data analysis of magnetic resonance experiments on kondo systems. (G. Fredericks)

2900 T Department of Computer Science. Text Recognition. Automatic formatting and reading of text. (J. Read)

2903 Datalogics Inc. Remote Support. We will be working on projects involving 360 for clients of Datalogics Inc. (L. Hollaar)

2904 Physics. Thermal Conductivity Analysis. I am measuring the thermal conductivity of a superconducting thin film which contains paramagnetic impurities. (A. Bjerkaas)

2905 T Accountancy. A Field Study of Role Conflict and Ambiguity in Organizations Internal Audit Staffs. (P. Delaney)

2909 T Food Science. Nutritive Value of Vegetables. Determination of the effect of processing methods and procedures on the vitamin and other nutrient content of vegetables. (M. Steinberg)

2910 T Psychology. Effect of Social Class on Labeling. The purpose of the proposed study is to test experimentally the effect of social class of the client upon the labeling behavior emitted by both professional and nonprofessional labelers. (J. Doty)

2912 Psychology. Graduate Records Information. To obtain descriptiv statistics on postcards sent to 1969 graduate applicants. (L. Cohen)

2914 Electrical Engineering. Noise Analysis. A multi-variable, evaluation function will be established for transmitting and receiving, active antennas. The computer will be used to find a set of variables which minimizes this evaluation function. (G. Deschamps)

2917 Chemistry. NMR Relaxation Phenomena. Calculation of rotational correlation times in molecular liquids from nuclear magnetic resonance relaxation experiments. (J. Jonas)

2918 Psychology. Attitude-Behavior Relations. Assessment of the contributions of several verbal measures, including attitude scales, to the predictability of church members' evert behaviors toward their church. (A. Wicker)

2921 Illinois State Water Survey. Cloud Physics Research. This research project will investigate problems related to cloud physics. (R. Semonin)

2925 T Electrical Engineering. Difference Games With Delays. The problem involves recursive solution and storage of certain coefficient matrices which will in turn be used to solve simultaneous difference equations. Dimensionality depends directly on the desired accuracy of the solution. Maximum use of memory space is anticipated. (J. Hanson)

2926 Education. Art objects--Affective Meaning. A Pilot Study to Identify and Evaluate Some of the Affective Dimensions of Art Objects. (G. Hardiman)

2928 Education. Basic Encounter Group Process and Outcome. Questionnaire responses and coded tape protocols of Basic Encounter Workshop participants, trainees, and staff will be analyzed using appropriate analysis of variance and discriminant function analysis. (T. Long)

2931 Electrical Engineering. Heat Transfer in E-Fields. Research is being done to understand the mechanism by which electric fields increase convection heat transfer. (R. Turnbull)

2933 Civil Engineering. Pavement Testing. Data Analysis. (E. Barenberg)

2936 Psychology. Individual and Group Decision. The evaluation of theoretical models of individual and group decision processes. (J. Davis)

2937 Education. The Values of Modernization. The values of modernization is a study of psycho-socio variables in a school and non-school Muslim population in Northern Nigeria. (A. Peshkin)

2941 Communications. Clausing ICR Army. General research on gun barrel heat transfer problems. (A. Clausing)

2943 Computer Science. ACM Algorithms. Processing of decks submitted to the Algorithms department of the Communications of the ACM. (L. Fosdick)

2944 University Office of School and College Relations. Admissions Research. Administrative research dealing with admissions policy. (J. Loeb)

2946 Mechanical Engineering. Ashrae Thermal Response. The project will consist of a numerical study of the transient thermal response characteristics of building sections. (C. Pedersen)

2949 Civil Engineering. Safety of Deep Submersibles. To develop probabilistic models for the analysis of structural safety of deep submersibles. (A. Ang)

2950 Advertising. Demographic Components. Study of interrelationships between a number of demographic characteristics. Sample based on Illinois farmers. Component data gathered from diary panels over 1 year period. (A. Barban)

2955 T Dairy Science. Linear Prog of Least Cost Rations. Lactating dairy cows fed in groups (3 pens) 3 levels of energy. Use of 4 trts. to determine optimum time to move a cow from one level of energy to a lower level as she progresses through lactation. (J. Harner)

2956 Accountancy. Simulation of Load-Curves. Simulation of electric utility load-curves for comparative study of capacity cost allocation methods. (D. Jensen)

2959 Materials Research Laboratory. Band Calculations in Solids. Hartree-Fock Techniques are to be applied to the studies of energy bands and the optical constants of insullating solids. (A. Kunz)

2963 T Geography. Mendocino-Atmosvariables. A study of atmospheric variables in selected sites on Cape Mendocino, California has been completed as of September 1, 1969, and the data from the project will now be analyzed to determine the character of air flow across several transverse ridges during the summer season. (G. Marotz)

2964 Institute for Research on Exceptional Children. Encounter Group Process Study. Debugging, extending, and analysis of FIRO-B Program and raw data from encounter group study. (E. Schultz)

2968 T Aeronautical and Astronautical Engineering. Subsonic Delta Wing Theory. A small perturbation matching procedure will be developed to calculate the lift on a delta wing with arbitrary aspect ratio. (C. Swain)

2970 Psychology. Training Culture. Studies of the induction of culturally disadvantaged persons in job situations. Will involve responses of both black and white subjects to a variety of psychological measures. (H. Triandis)

2971 Agricultural Engineering. PSD Signal Analysis. Power spectral density analysis techniques will be further developed for the evaluation of vibration and noise data. (R. Yoerger)

2972 Materials Research Laboratory. Data Analysis for Trans-Carb. Studies of properties of transition metal compounds. (W. Williams)

2973 T Psychology. Evaluation of Counsel and Desensitization in Alleviating Test Anxiety. Project is to assess relative effectiveness of group desensitization and study counseling in improving academic performance and alleviating "test anxiety" in undergraduate students. (G. Allen)

2974 Chemistry. Molecular Dynamics. Detailed dynamics of molecular collision. (R. Marcus)

2975 T Chemistry. X-Ray Crystal Analysis. This time will be used for the solution of solid state structures using single crystal X-ray data. (G. Stucky)

2976 T Education. Kentucky Student-Centered Course. This research project makes use of a pre-post test design with various control groups and utilizes multivariate analysis of variance and covariance. The project is concerned with the effects of a student-centered, self-development course on personality factors. (J. Gulden)

2977 T Civil Engineering. Gamma Transport in Concrete. Monte Carlo methods will be applied to gamma ray transport problems in concrete. Investigations will be carried out of buildup factors for deep penetration, interface effects, and heterogeneous effects. (T. Carlsøn)

2978 Horticulture. Herbicide Efficacy. Comparative herbicide efficacy and activity studies. (H. Hopen)

2979 T Psychology. Modeling in Schizophrenics. A study of the effects of presenting 2 models and 3 sets of consequences to the models on the verbal behavior of two populations of schizophrenic inpatients was executed. A repeated measures design was used. 15 variables are involved. $N_1 = 80$ and $N_2 = 30$. Intercorrelations and matrix operations will be required. (S. Brenman)

2996 T Agricultural Engineering. Multidimensional Water Balance. Development of a model for determining the effect of irrigation design parameters using available climatic data, so that optimization techniques may be applied. (R. Godwin)

3004 Psychology. Fear Assessment Study. Analyses of data generated by fear questionnaire as well as actual programmed contact with a variety of fear stimuli. (D. Bernstein)

3005 Bureau of Institutional Research. Administrative Research. Analyses of data concerning activities and characteristics of the staff of the University of Illinois. (F. Duff)

3007 Vocational and Technical Education. REDY. Rural Education for Disadvantaged Youth USOE Contract. (L. Phipps)

3008 Institute for Research on Exceptional Children. Testing Color Vision of Retardates. Criterion validity study of four tests of color vision. (J. Salvia)

3009 T Sociology. Sociological Careers. Study of the achievement of success by sociological practitioners. (C. Mettlin)

3012 T Chemistry. Buoyancy-Driven Cellular Convection. Studying cellular convection due to an adverse density gradient brought upon by mass transfer. (E. Burger)

3013 T Electrical Engineering. Reading Tape Data To Cards. Radio propagation research. (R. Beckwith)

3014 Economics. Quadratic Programming Estimate. This time will be used to continue work on a Monte Carlo Experiment for Quadratic Programming Estimations started under Problem No. 1935 whose time expired September 1, 1969, by date rather than use. (T. Yancey)

3016 T Electrical Engineering. Electrohydrodynamics. Heat transfer in electric fields. (H. Ochs)

3017 Survey Research Laboratory. Study 045 Cleaning. Cleaning data for faculty benefits study. (R. Ferber)

3020 T Chemistry. Raman Spectroscopy. Investigations into the intensities of Raman lines and quantitative analysis of a mixture of compounds in a sample by use of photon counting techniques. This includes much data handling using appropriate statistics for each compound. (R. Malmstadt)

3021 Student Counseling Service. Interest Test Analysis. Analysis of two tests (Survey of Interests and Personal Rating Form) by computing intercorrelations of items, factor analyses, and performing statistical validation tests in order to determine the usefulness of academic and personal interest factors in predicting success and persistence of students in various curricula in the University. (T. Ewing)

3028 Sociology. Social Change and Social Violence. An investigation of the relationship between unbalanced changes in the educational and occupational system in nations and the volume of political violence occurring between 1955 and 1961. (L. Southwood)

3029 T OPT of Unheated Air Drying. Weather data on magnetic tapes will be used to develop frequency distributions of required and allowable drying times as functions of a number of variables. The probability of successful operation will be determined for various combinations of these variables. (P. Bloome)

3035 Psychology. Memory In Retarded Children. Study of Discrimination Learning in Retarded Children. (K. Scott)

3037 Electrical Engineering. Random Antenna Arrays. Computation of Mutual Coupling Effects in Phased Antenna Arrays. (Y. Lo)

3042 Chemistry. Analytical Mechanics of Reactions. Analytical mechanical treatment of chemical reactions using a Hamilton-Jacobi formalism. (S. Wu)

3046 T Aeronautical and Astronautical Engineering. Turbulent Boundary Layer. A numerical method would be used to solve the turbulent boundary layer equations with service blowing. (H. Kerzner)

10.3 Class Problem Specifications

During the third quarter of 1969, 132 problem specifications were submitted to cover all assigned problems on the System/360 in the following courses.

2677	Theoretical and Applied Mechanics 493.
2687	Finance 490.
2699	Architecture 494.
2712	Psychology 493.
2730	Psychology 235.
2750	Nuclear Engineering 411.
2781	Industrial Engineering 401.
2784	Psychology 293 and 294.
2791	Elementary Education 433.
2794	Aeronautical and Astronautical Engineering 391.
2796	Plant Pathology 302.
2798	Mechnical Engineering 421.
2809	Animal Science 103.

2815 Civil Engineering 262.

2816 Finance 294.

2827 English 297.

2829 Educational Psychology 496.

2830 Educational Psychology 490.

2832 Psychology 292.

2840 Secondary Education 449.

2841 Mathematics 263.

2842 Accountancy 199.

2843 Recreation 403.

2845 Agricultural Engineering 276.

2853 Business Administration 373.

2855 Civil Engineering 497.

2861 Mechanical Engineering 293.

2863 Marketing 473.

2864 Accountancy 493.

2868 Urban Planning 376.

2874 Electrical Engineering 272.

2883 Accountancy 325.

2884 Chemistry 107.

2887 Aeronautical and Astronautical Engineering 260.

2888 Aeronautical and Astronautical Engineering 438.

2889 Economics 294.

2890 Mechanical Engineering 323.

2891 Computer Science 101.

2894 Engineering Honors Program 198.

2895 Nuclear Engineering 431.

2896 Agronomy 365.

2897 Agronomy 340.

2898 Agronomy 493.

2901 General Engineering 103.

2902 Business Administration 552.

2906 Mechanical Engineering 293.

2907 Mechanical Engineering 250.

2908 Mechanical Engineering 428.

2911 Civil Engineering 474

2913 Computer Science 201.

2915 Economics 470.

2916 Chemistry 446

2919 Computer Science 101/103/105/107/121/400.

2920 Mechanical Engineering 271.

2922 Mechanical Engineering 263.

2923 Civil Engineering 220.

2924 Mechanical Engineering 259.

2927 Mechanical Engineering 264.

2929 Geology 479.

2930 Civil Engineering 391.

2932 Agricultural Engineering 311.

2934 Chemistry 383.

2935 Computer Science 457.

2938 Computer Science 397.

2939 Electrical Engineering 451.

2940 Electrical Engineering 260.

2942 Music 343.

2945 Computer Science 301.

2947 Educational Psychology 449.

2948 Mechanical Engineering 341.

2951 Computer Science 103.

2952 Engineering Honors 297D.

2953 Mechanical Engineering 306.

2954 Civil Engineering 322.

2957 General Engineering 288.

2958 General Engineering 393.

2960 Electrical Engineering 386.

2961 Electrical Engineering 454.

2962 Civil Engineering 201.

2965 General Engineering 221.

2966 Chemistry 394.

2967 Chemistry 392.

2969 Biophysics 410.

2980 Mechanical Engineering 448.

2981 Aeronautical and Astronautical Engineering 225.

2982 Theoretical and Applied Mechanics 235.

2983 Physics 303

2984 Computer Science 387

2985 Nuclear Engineering 458.

2986 Theoretical and Applied Mechanics 392.

2987 Physics 342.

2988 Civil Engineering 361.

2989 Geography 495.

2990 Electrical Engineering 389.

2991 Psychology 494.

2992 Psychology 409.

2993 Sociology 386.

2994 Electrical Engineering 416.

2995 Social Work 491.

2997 Agricultural Engineering 286.

2998 Mechanical Engineering 256.

2999 Psychology 390.

3000	Geology 331.
3001	Geology 430.
3002	Aeronautical and Astronautical Engineering 263.
3003	Electrical Engineering 323.
3006	Business Administration 472.
3010	Civil Engineering 250.
3011	Chemistry 385.
3015	Electrical Engineering 299.
3018	Chemistry 367.
3019	Mechanical Engineering 448.
3022	Chemistry 349.
3023	Mechanical Engineering 342.
3024	Computer Science 287.
3025	Agricultural Economics 325.
3026	Agricultural Economics 425.
3027	Agricultural Economics 341.
3030	Political Science 496.
3031	Civil Engineering 261.

3032 Civil Engineering 263.

3033 Computer Science 491.

3034 Computer Science 290.

3036 Civil Engineering 473.

3038 Sociology 184.

3039 Chemistry 466.

3040 Educational Psychology 490.

3041 Theoretical and Applied Mechanics 224.

3043 Mechanical Engineering 220.

3044 Electrical Engineering 251.

3045 Civil Engineering 482.

3047 Electrical Engineering 383.

11. GENERAL DEPARTMENT INFORMATION

11.1 Personnel

The number of people associated with the Department in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	24	1	24.50
Visiting Faculty	8	0	8.00
Research Associates	2	0	2.00
Graduate Research Assistants	7	101	58.17
Graduate Teaching Assistants	0	19	8.75
Professional Personnel	36	3	38.17
Administrative and Clerical	29	0	29.00
Nonacademic Personnel (Monthly)	71	1	71.75
Nonacademic Personnel (Hourly)	--	102	41.02
TOTAL	177	227	281.36

The Department Advisory Committee consists of Professor J. R. Pasta, Head of the Department; Professor J. N. Snyder, Associate Head of the Department; Professors K. W. Dickman, M. Faiman, L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J. Nievergelt, R. S. Northcote, J. R. Phillips, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, P. E. Saylor, and D. L. Slotnick.

11.2 Bibliography

During the third quarter, the following publications were issued by the Laboratory:

File Numbers

(1) Bernhard, Winfried H., "A Matrix Inversion Program for Illiac IV," File No. 814, July 8, 1969.

(2) Carter, C. E., "Hardware Measurements of the I.B.M. 360/50 and 360/75," File No. 802, July 30, 1969.

(3) Carter, C. E., "1969 Illinet Hardware," File No. 812, September, 1969.

(4) Franco, Sergio, "Dynamic Focusing and Pincushion Correction Circuit forthe Illiac III Display System," File No. 805, August 12, 1969.

(5) Gold, David E., and Henderson, Jr., D. Austin, "An Algorithm for Obtaining a Minimum State Variance, Minimum Time, Critical Race-Free State Assignment for Asychronous Machines," File No. 803, August 12, 1969.

(6) Knowles, Michael H., "A Shadow Algorithm for Computer Graphics," File No. 811, September 22, 1969.

(7) Marceau, I. W., Lermit, R. J., McMillan, J. C., Yamamoto, T., and Yardley, S. S., "Linear Programming on Illiac IV," File No. 808, September 1, 1969.

(8) Matsushita, Yutaka, "Hidden Lines Elimination for a Rotating Object," File No. 801, July 2, 1969.

(9) Stevens, Jr., James E., "A Kalman-Filter Tracking Program for Illiac IV," File No. 804, August 13, 1969.

(10) Trout, H. Robert G., "An Illiac IV Language," File No. 809, September 9, 1969.

(11) Wang, Paul J., "Romberg's Method in Numerical Quadrature," File No. 806, July 1, 1969.

(12) Whiteside, Stephen E., "Specifications for Laser Beam Deflectors," File No. 550-133, July 24, 1969.

(13) Yasui, Toshio, "Programming the Tillotson Equation of State on Illiac IV," File No. 807, August 20, 1969.

Report Numbers

(1) Beals, Alan J., LaFrance, Jacques E., and Northcote, Robert S., "The Automatic Generation of Floyd Production Syntactic Analyzers," Report No. 350, September 9, 1969.

(2) Illiac III Staff, "Part I: Technical Progress Report," Report No. 342, July 23, 1969.

(3) Marvel, O. E., "'Model T' - A Demonstration of Image Multiplication Using Stochastic Sequences," Report No. 349, August, 1969.

(4) Nordmann, Jr., Bernard J., "Illiac III Computer System Manual: Taxicrinic Processor," Volume I, Report No. 341, July, 1969.

(5) Quarterly Progress Report -- Illiac IV, April - June, 1969," Report No. 360, August 1, 1969.

(6) Schwebel, John C., and McCormick, Bruce H., "Consistent Properties of Composite Formation Under a Binary Relation," Report No. 348, August 12, 1969.

Theses

(1) Allegre, Nicole Genevieve, "TESLA, A Control Language for Logic Simulations of Digital Circuits," (M.S.), Report No. 347, August 8, 1969.

(2) Cheng, Tien-Ren Richard, "The Hardware Design of a Cognitive Model Demonstrator," (M.S.), Report No. 345, August, 1969.

(3) Flowerdew, Stanley J., "An Analysis of Some Eulerian Methods for One Dimensional, Inviscid, Compressible Hydrodynamics," (M.S.), Report No. 352, September 22, 1969.

(4) Hostovsky, Raphael, "Design of a Display Processing Unit in a Multi-Terminal Environment," (M.S.), Report No. 343, July 30, 1969.

(5) Kraska, Paul William, "Array Storage Allocation," (M.S.), Report No. 344, August 1, 1969.

(6) Lermit, Raymond J., "An Error Analysis of Solutions to Sparse Linear Programming Problems," (M.S.), Report No. 351, September 17, 1969.

(7) Michel, Martin Joel, "Graphical Remote-Access Simulation System (GRASS). The Communication and Monitor Components (GASP/GLASP)," (M.S.), Report No. 346, August 8, 1969.

11.3 Colloquia

"Computer Aided Design Using Computer Graphics," by Dr. Heinz U. Lemke, Cambridge University, Cambridge, England, September 15, 1969.

"The Degree Hierarchy of Undecidable Problems of Formal Grammars," by Professor Dennis F. Cudia, University of Wisconsin, Barabau, Wisconsin, September 29, 1969.

11.4 Drafting

During the third quarter, a total of 551 drawings were processed by both drafting sections:

	General	Pattern Recognition
Large Drawings	29	51
Medium Drawings	82	31
Small Drawings	150	73
Layouts	2	2
Report Drawings	22	28
Changes	20	32
Miscellaneous	27	2
TOTAL	332	219

(M. Goebel and S. Zundo)

11.5 Shops' Production

Job orders processed and completed during the third quarter of 1969 are as follows:

	AEC 1018	AEC 1469	Other
Machine Shop	15	13	3
Electronics Shop	26	27	4
Chemical Shop	10	20	6
Layout Shop	15	20	1
TOTAL	66	80	14

(F. Serio)

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Physics

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QUARTERLY TECHNICAL PROGRESS REPORT

October, November, December 1969

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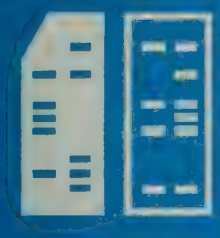

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN · URBANA, ILLINOIS

QUARTERLY TECHNICAL PROGRESS REPORT

October, November, December 1969

Department of Computer Science
University of Illinois at Champaign-Urbana
Urbana, Illinois 61801

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1. CIRCUIT RESEARCH PROGRAM

(Supported in part by the Office of Naval Research under Contract N000 14-67-A-0305-0007, W. J. Poppelbaum, Principal Investigator)

Summary

Mehernosh Cooper has a report on the LASCOT detection system, viz, the equipment used to decompose the light from the scanned picture into its primary color components. The bundle processor (BUM) has been taken over by Daniel Coombes, who discusses the effect of the form of signal encoding on failsafe operation. Eidolyzer is a new project, being undertaken by Art Simons under the supervision of Professor S. R. Ray. Its objective is the design of a machine capable of extracting features from two-dimensional scenes, using a hierarchy of "levels" of information, including color. Yiu Wo and David Olsen are engaged in another new project, APE (sic). Their aim is to design an "autonomous processing element" which can communicate with like elements and also derive its operating power solely via radio waves, obviating any need to be wired to its environment. The final goal of this project is a computer of variable structure, comprising a control and many APEs.* Finally, Hadjistavros' report on Colormatrix summarizes his results on the thermal behavior of transistors and encapsulated liquid crystals.

M. Faiman

*Arthur C. Clarke, "2001 a space odyssey", Chap. 1, pp. 20-23, Signet Books (paper), 1968.

- Ed.

1.1 Lascot (Project No. 09)

The deflection system, as described in the last two reports, is working satisfactorily. The dichroic mirrors have been procured. The high voltage power supply has been built and load tested. The complete detection system is in the process of being tested. This consists of three photomultipliers PM1, PM2 and PM3, as shown in Figure 1. The white light input comes from the deflection (galvanometer) mirrors which scan a TV monitor. The dichroic mirror DM1 transmits red light and reflects blue and green; similarly, DM2 transmits green light and reflects blue and red. With the configuration given in Figure 1, it is immediately obvious that PM1, PM2 and PM3 receive red, blue and green light respectively. The photomultiplier PM1 is an RCA-4472, having an S4 type of response, with extended sensitivity in the red. PM2 and PM3 are both RCA-931-A.

The biasing network for the photomultipliers is shown in Figure 2. Each photomultiplier output is fed to a video preamplifier and then through a video amplifier to drive the EOLM.

The video driving amplifiers are being tested.

M. N. Cooper

1.2 BUM (Project No. 21)

1.2.1 Attrition Problem

At first the use of three level logic circuitry looked like a useful solution to the attrition problem. After further development, three level logic proved to defeat the simplicity of bundle processing which represents information on a large bundle of wires using only a high or low state for each wire. Three level logic also complicated the boolean expressions for the different arithmetic operations and the problems of making these operations failsafe. Another solution which involved using only half the bundle to represent a number was also found to be undesirable because only negative numbers could be represented using present mappings.

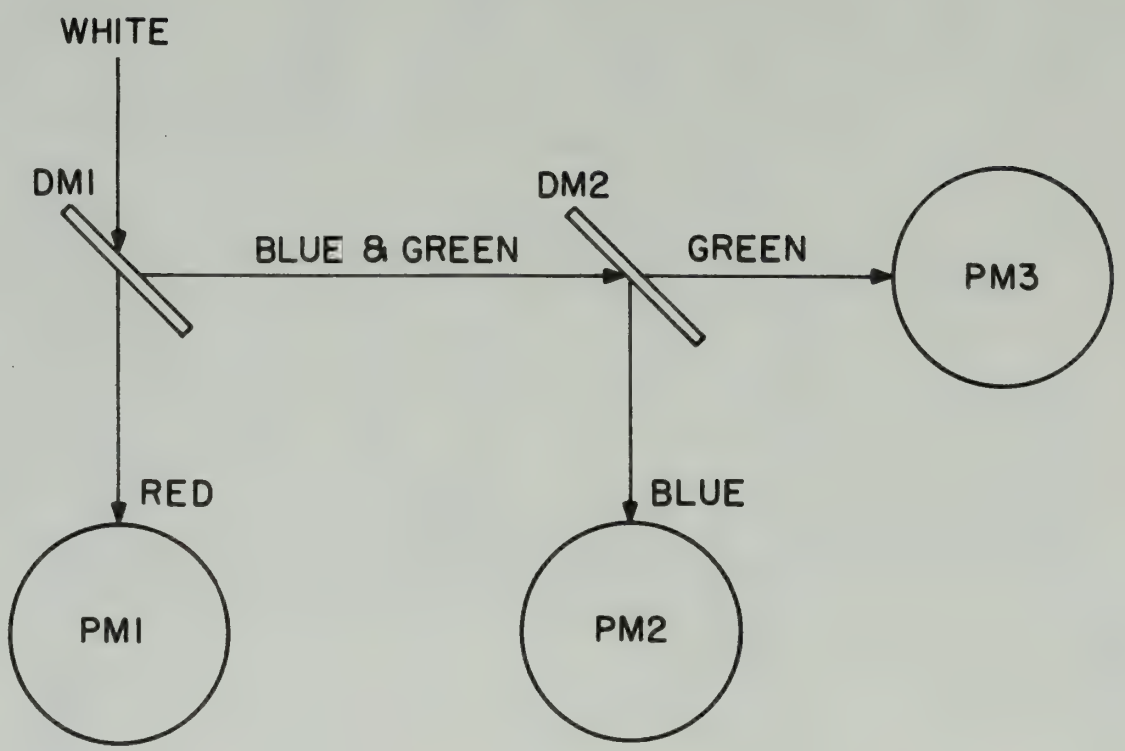

Figure 1. Detector

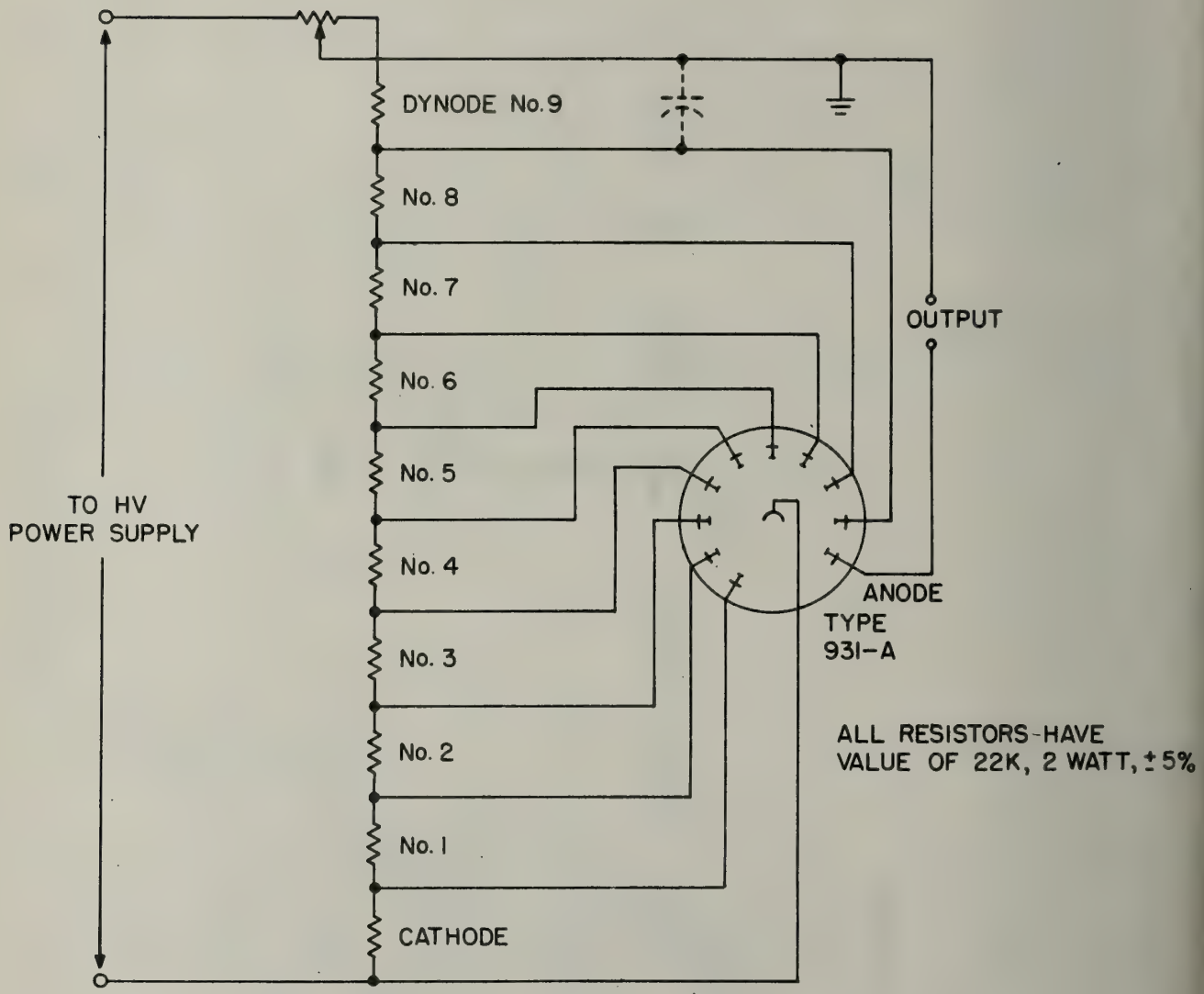

Figure 2. Photomultiplier Biasing Circuit

1.2.2 Failsafe Processing

The use of two bundles to represent a number makes failsafe processing a possibility. If arithmetic operations are failsafe, then the results will be independent of circuit failures. The two mappings

$$Y = \frac{2x_1 - 1}{2x_2 - 1}$$

and

$$Y = \frac{x_1}{x_2} - \frac{m}{2}$$

have been investigated for their failsafe possibilities, but so far neither one is completely satisfactory. Y is the number to be represented, x is the value of a bundle, and n is the number of wires in a bundle. After a satisfactory failsafe mapping has been found, the necessary circuitry will be designed.

Daniel Coombes

1.3 Eidolyzer (Project No. 23)

1.3.1 Description of the system

No great conceptual sophistication is required to build a machine that works along the same principles as the human arm because the principles of leverage and constriction involved in this action are understood. But we do not understand the human behavior associated with the recognition of patterns with comparable clarity and thoroughness.

It is proposed that a picture analysis system be constructed based upon the idea that, as a human has more or less information about a particular subject, the greater or lesser will be the accuracy of his decisions concerning that subject. As the information proceeds from the more general to the specific, it constrains the inferences made by humans concerning the identity of subjects and conditions. In the present case, only perceivable objects and four levels

of information will be considered. The most general level of information (level 1) is assumed, arbitrarily, to be that all the pictures are landscapes.

It is desired to project a slide of the desired scene onto a 16 x 16 array of groups of photocells. At each of the 256 points of the array, three photocells, reacting to only red, green or blue, respectively, will decode the color of the slide at that point. A total of six colors are used to make the slides: red, green, blue, brown, black and white.

The next step in the process is to determine the "color" of each of the 16 rows in a slide. It has been decided arbitrarily that if any row has a definite majority (i.e., 9 or more out of 16) of points of one color, then that color alone will be assigned to the entire row.

The colors of the details in the scene (e.g., a cloud in the sky) are also determined simultaneous with the colors of the rows.

Next, the rows are divided into contiguous blocks of the same predominant color. The colors of the regions represent level 2 of the information. This provides sufficient data to hypothesize the nature of the scene. For example, a slide with three regions - blue at the top, green in the middle, and brown at the bottom - could be hypothesized to be sky, grass, and earth. This decision is subject to change if subsequent data is strongly contradictory. The subsequent data are the color of the details in the different regions (level 3 of the information) and imperceived conditions such as humidity and temperature (level 4).

Finally, hypothesized conditions will be presented as labels of regions and details displayed on a panel.

1.3.2 Design Progress

The block diagram of Eidolyzer is shown in Figure 1. At present, work is being done on the "brain" of the system, the World Model. Considerable work has been done in the other areas but nothing is finalized yet because, at this early stage, many of the goals of the project are in the process of change.

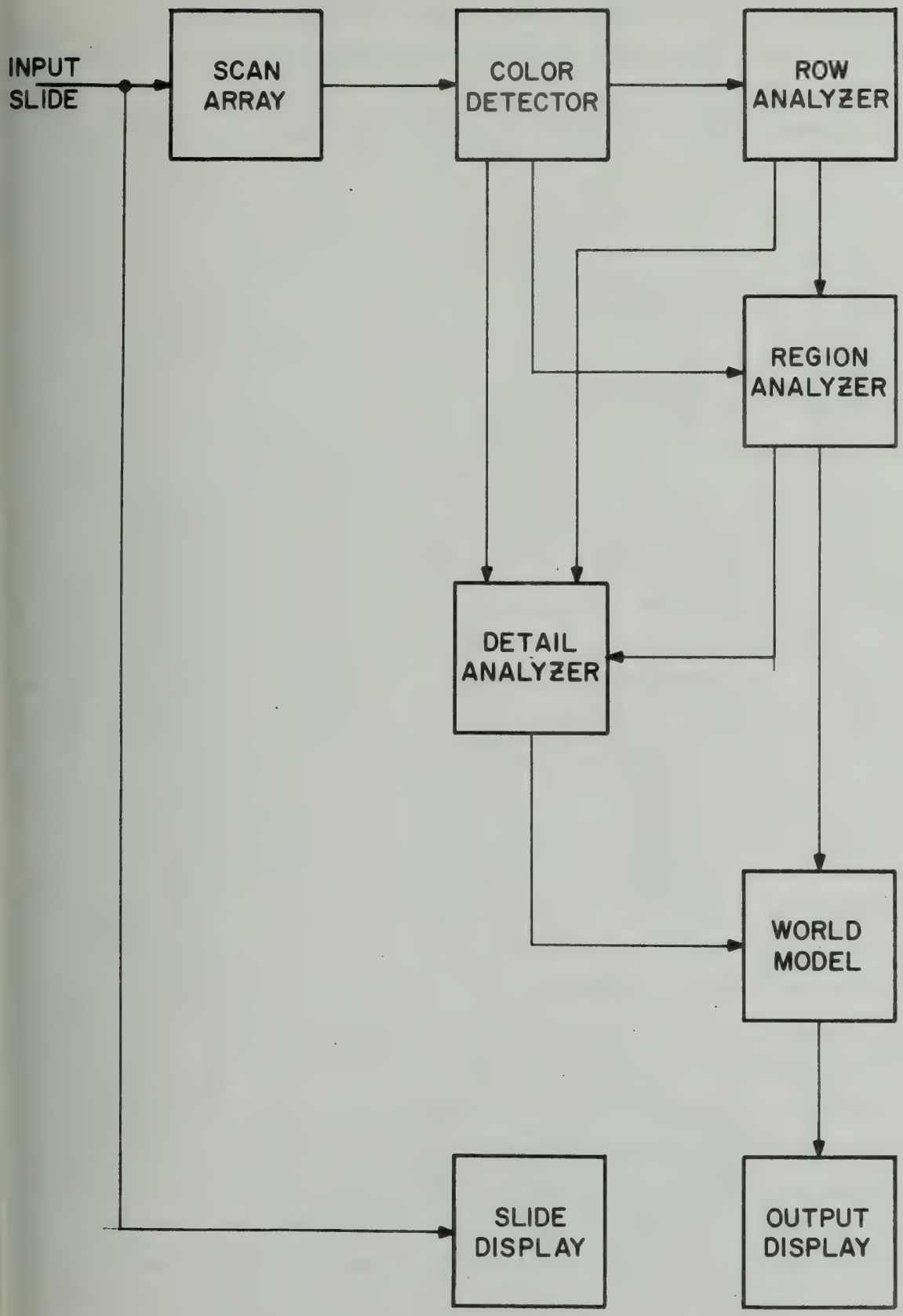

Figure 1. Eidolyzer: Block Diagram

The only hardware design so far has been confined to determining the colors of the slide. Owing to the difficulty in getting a photocell to respond greatly to blue light, various schemes utilizing different photocells and Wratten filters have been tried. To date, I have been unable to differentiate between blue and red light. Further tests will be conducted with lighter hues of blue.

Arthur Simons

1.4 APE (Project No. 25)

1.4.1 Introduction

Preliminary work on a new project called APE (Autonomous Processing Element) has started this quarter. This project involves the study and construction of a computer which does not have to be assembled into a wired physical network. A proposed machine of this type is shown in Figure 1. It consists of a control unit, a number of autonomous processing elements known as APEs, and a number of sensors as data sources. These constituents of the computer are interconnected through radio frequency channels only. Each APE has two tunable input channels and a fixed output transmitting channel. Therefore, each input channel can be linked to the output of any APE or sensor. An APE can perform on its two input data any one of the operations of addition, subtraction, multiplication, division and storage. The tuning of the inputs as well as the setting for the APE to perform a specific operation are done remotely through radio linkage with the control unit. This allows the APEs and the sensors to be connected in suitable structures to perform a specific variety of functions. This programming process can be carried out by setting the i and j values for each of the APEs involved, as symbolized by the i, j and k dials in Figure 1.

As another feature of this computer, the encoding of the information in the radio channels is such that the operation of many outputs of the APEs on one channel, i.e. having identical transmitting frequencies, does not affect the overall performance of the system. This means that both redundancy of a given output channel and the lack of any particular channel are allowed. To take into account the latter case, the existence of a

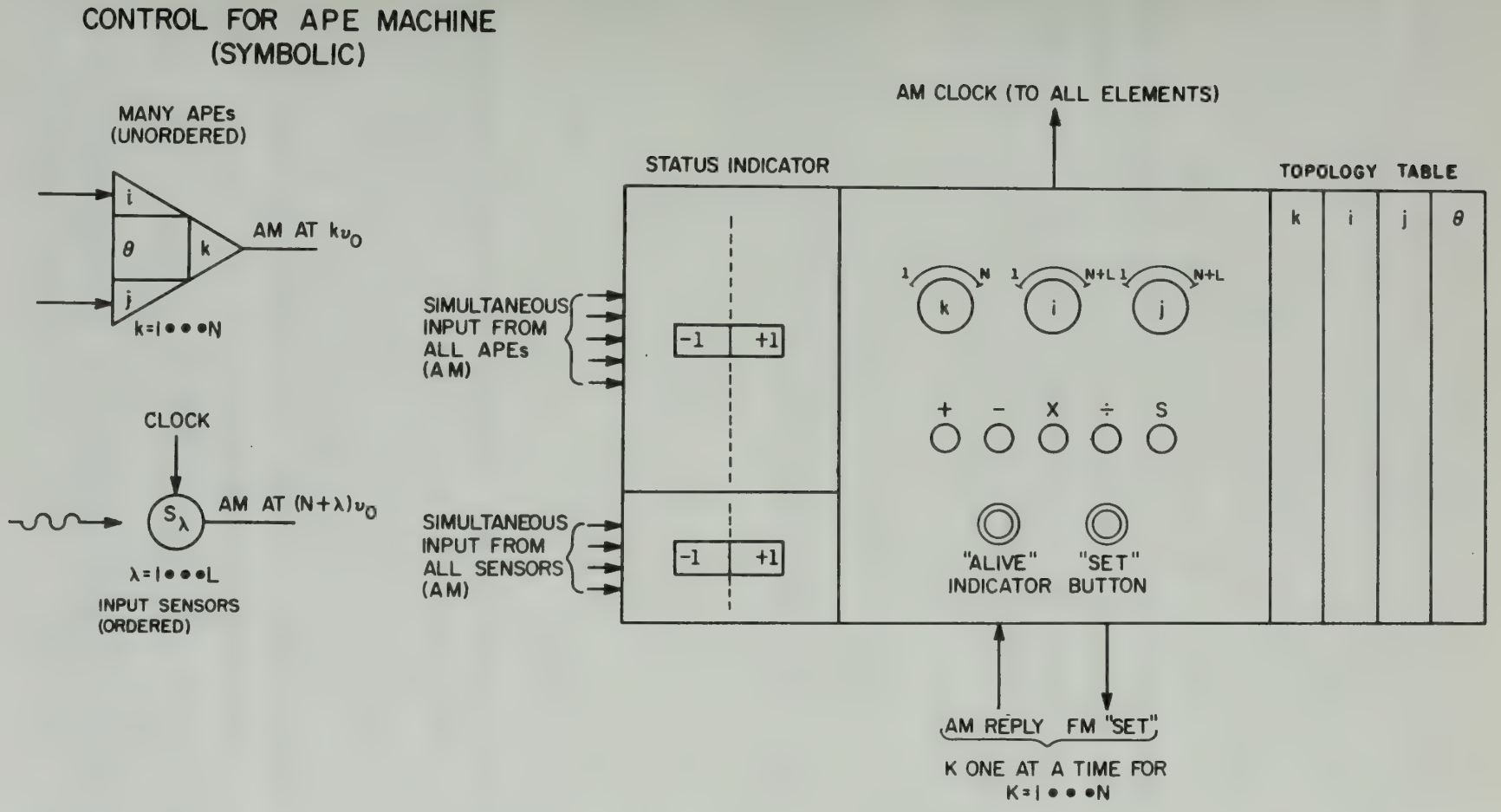

Figure 1. The APE Machine

particular APE has to be tested before any attempt is made to establish interconnections between it and other units. This test is performed by observing the response to a call to the APE in question from the "Alive" indicator of the control unit.

The input data to the computer are provided by the sensors. These data are processed by an array of APEs in an appropriate tree structure for a particular job function. All input data from the sensors, as well as all intermediate and final results from the APEs, are monitored by the status indicator of the control unit, as shown in Figure 1. To facilitate the specific encoding methods and to synchronize the operations of all APEs and sensors, an amplitude modulated clock is sent to all of them. The topology table shown in the figure simply serves as a record of the current program of the computer.

In addition to the features described above, it has been planned to power the APEs remotely. Great effort has been made in investigating the feasibility of this approach. More details on this aspect are described in the next section.

Yiu Wo

1.4.2 APE Power Transfer

Initial experiments were conducted with simple half-wave dipole antennas. The transmitting end consisted of a Rhode and Schwarz transmitter set at 350MHz and connected to a 16 inch dipole. The receiving end consisted of an identical dipole connected to a full wave bridge of 1N82 diodes. Approximately 10 volts dc were measured with a Simpson meter as a load, an antenna separation of about five feet, and a transmitter power of about 1.5 watts (The transmitter power reading was not exact since the dipole impedance did not match the 50 ohm transmitter output.). With a greatly reduced antenna separation, a 6 volt 40 milliampere bulb could be powered.

The size of an APE is visualized as being much smaller than a 16 inch dipole would permit. Operation at 1.3GHz is being pursued; this

frequency requires a dipole size of about 4.3 inches. Construction of a 220MHz 40 watt transmitter is in progress. Parts have been ordered for frequency multiplying circuits to go to 1.3GHz.

David L. Olsen

1.5 Colormatrix (Project No. 27)

1.5.1 Summary

The thermal behavior of transistors as well as of encapsulated liquid crystals was tested. A simple pulse system was developed and will be tested on a matrix display.

1.5.2 Thermal Behavior of Transistors

Transistors of interest were tested. Their thermal behavior is summarized as follows:

1. The increase of average temperature of the case, ΔT_{AV}, is proportional to the product duty cycle and pulse power, as was to be expected. The speed of increase of T_{AV} is also a linear function of the above product for limited regions of operation.
2. A thermal signal of measurable amplitude appears only if, for given pulse power, the duty cycle is such that there is enough time for the dissipation of the injected heat. Otherwise the bigger part of the power contributes only to the increase of T_{AV}.
3. A delay always exists between the applied power pulse and the thermal signal.

The orders of magnitude of the duty cycle, the dissipation time as well as the delay, are, for given ambient temperature, functions of the thermal mass of the transistor and the thermal resistance between the base-collector junction and the case.

1.5.3 Thermal Behavior of Encapsulated Liquid Crystals

From the present applications, encapsulated liquid crystals on a mylar substrate were tested. They responsed very fast to the temperature changes; however they didn't give a complete succession of the colors of the whole visible spectrum. At both ends of their predetermined range of operation, they appeared brown or black colored, seeming "saturated" or "cut-off".

The objective of the display is to switch on the desired color as fast as possible, to keep it exactly at the appropriate temperature, without pushing it into saturation, and turn it off as fast as possible to the threshold temperature, in order to be ready for the display of the new information. For this a simple pulse system has been developed and has to be tested on a display matrix.

S. Hadjistavros

2. HARDWARE SYSTEMS RESEARCH

(Supported in part by the Atomic Energy Commission under Contract No. US AEC AT(11-1) 1469, W. J. Poppelbaum, Principal Investigator.)

Summary

Parts of the OLFT electron beam deflection circuitry have been changed to improve image resolution. This is described by Doug Sand, who also discusses preliminary calculations on the thermal stability of a Curie temperature system. Dennis Kodimer has a report on the new alphechon subsystem that he is putting together. The Tricolor Cartograph is being modified to include a TV camera for the insertion of outlines. Don Hanson discusses this, as well as some work on removing the narrow vertical bar system from the display. Larry Ryan's Transformatrix report deals with determining values for the ladder resistors in the system's D/A converter, and with a diode decoder used for the coefficients in the Fourier Transform operation. BLAST has undergone some changes at Larry Wallman's hands: the video chopper and mixer circuit has been added to, and the synchronization scheme modified. The special CRT had sprung a leak and had to be returned to the manufacturer. (It is now back in house and working - ed.) Semantrix is a new project, undertaken by Trevor Mudge under the supervision of Professor Ray. It is to be an intelligent machine capable of synthesizing a physical scene on the basis of a suitable world model. Dick Blandford also has a new project - LINDA, for line drawing analyser. The technique being considered here is to write a two-dimensional line drawing on the face of a CRT whose periphery contains a ring of photodetectors. By varying the scale of the drawing it is hoped to be able to extract information about its contents depending on how the constituent lines cross the periphery. The Stereomatrix report is in its, by now customary, four parts: Chuck Pirnat describes the VHF phase detection of the observer's position; Dick Cheng writes about the system design and coefficient generator; Shiv Verma has descriptions of a very fast analog gate and a D/A converter using an R-2R ladder; while Steve Whiteside agonises over problems encountered with the laser.

M. Faiman

2.1 OLFT (Project No. 12)

2.1.1 System Modifications

While starting the resolution tests, it was found that the deflection signals contained much noise. The deflection waveforms are ramps of about 1.5 volts magnitude, while the noise was about 10mV rms, producing a "jitter" of about 1%. This noise was faithfully reproduced by the yoke drivers, introducing significant defocussing and loss of resolution for spatial frequencies above about 100 line pairs. This noise was traced to two sources: ground-loop noise on signal cables, and insufficient buffering in converting the digital drive pulse signals into analog retrace signals. These noise sources were eliminated, reducing the observed noise to about 2mV peak maximum (less than 0.1%).

The ground-loop noise appeared on the shields of the 20' cables connecting the ramp voltage generator outputs and the yoke driver inputs. This noise was reduced to less than 1mV peak to peak by a differential amplifier buffer at the input of each yoke-driver amplifier. One such buffer amplifier is shown in Figure 1. The output impedance of the ramp generator (about 1000 ohms) is matched by adjusting the variable resistor at the inverting input.

The other noise source was traced to the ramp voltage generators, primarily caused by inadequate buffering between the digital (TTL) drive pulse generators and the retrace circuit of the ramp generators. Originally, the retrace had been controlled by an internal flip-flop, which was later by-passed, to inject the drive-pulse signal directly into the retrace transistor. Normally, this transistor could have converted the digital drive pulse into the appropriate analog current pulse, but too much noise was present on the digital signal. To correct this, the original flip-flop was reconnected in each generator, although the trigger point was changed to be compatible with the drive pulse. This restored the original "purity" of the voltage ramp. In addition, the keystone correction generator was "stabilized" to remove some high-frequency oscillations which appeared on the horizontal output ramp. Finally, minor modifications were made to give more resolution to the gain and bias controls, reducing the maximum output voltage from about 10 volts to about 2 volts.

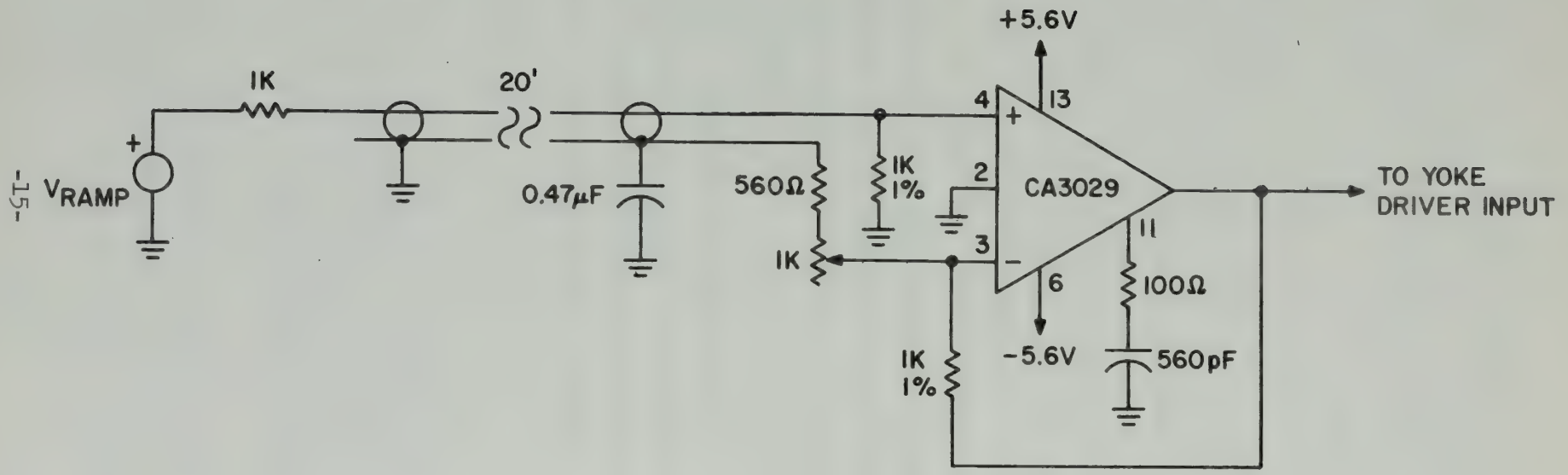

Figure 1. Buffer Amplifier for Deflection Yoke Driver

2.1.2 Investigation of Temperature Effects

It has been suggested that significant advantages can be obtained by operating the light valve with the crystal cooled to its Curie temperature T_c (about 220°K for KD*P).[1] At T_c the longitudinal dielectric constant ϵ_c (about 50 at room temperature) is about 650, while the transverse dielectric constant ϵ_a remains at about 40. This has two primary effects. First, the longitudinal electro-optic coefficient r_{63} is proportional to the product $\epsilon_c\epsilon_a$, and increases accordingly, so that the half-wave voltage $V_{1/2}$, inversely proportional to r_{63}, decreases considerably. This allows the use of low velocity electron beams (~ 1000 eV) and also permits an advantageous storage-erase mechanism described in the first reference cited. In addition, the effective crystal thickness[2] is proportional to $(\epsilon_a/\epsilon_c)^{1/2}$, so that, for example, a 10 mil crystal thickness at T_c gives the same resolution as a 2.5 mil crystal at room temperature.

These operational advantages appear very attractive, and we are currently investigating the changes necessary for Curie-temperature operation. The first consideration is the thermal structure required to maintain uniform characteristics throughout the crystal. Under constant strain (the crystal is glued to its substrate) the value of ϵ_c near T_c remains very constant over a range of about 4°K. Preliminary calculations show that the present crystal assembly would present a temperature variation of about 3°K throughout the crystal if the input power is 0.2 watt (about twice the anticipated value) and if the substrate is held at constant temperature along two edges. The necessary temperature control can easily be obtained by a cascaded thermo-electric heat pump together with a thermistor-controller.

Thus thermal considerations do not appear to present serious difficulties. On the other hand, the necessary changes in the electronics of the system are considerably more complicated, although here also no serious difficulties are anticipated. Further discussion of Curie-temperature operation will appear in a subsequent report.

Douglas Sand
Chin-Lon Lin

References

1. G. Marie, "The Titus Tube", Philips Res. Repts. 22, 110-132, 1967.

2. Report No. 303, Department of Computer Science, University of Illinois, Urbana, 1969.

2.1.3 Alphechon Subsystem

A second alphechon subsystem to OLFT is under construction. The first system was found to have many ills: intolerable drift in the erase/write potentials generated at the alphechon, low bandwidth video amplifiers, and a massive volume of power supplies.

The second system is being constructed in a much smaller volume, with all controls and power supplies internal. Plug cards are used extensively, with wire wrap connectors. The minimum bandwidth of all video circuits has been set at 4MHz. This brought about the first major deviation from the RCA suggested circuits: driving the cathode of the alphechon. The lower impedance allows further positive feedback in the driver to extend its bandwidth, and enables the driver to be semi-remote from the alphechon, which was physically necessary. The second major deviation from RCA is in the potential drivers. The read/erase/write signals are logical (not analog, as in the first version) and drive common base current summation stages. The resulting drivers consume much less power and their drift is less than 2%.

2.1.4 Current Status

At present, the power supplies are all functional. There are five supplies for the alphechon system, and two additional supplies for the Cohu camera cards which will be used. No Cohu power supply card will be used. The Cohu cards that are being used are being floated from the original alphechon system.

A single plug card generates the erase/write/read cycle and is operating. The period between rewriting is continuously variable from ~1 sec to ~ 60 secs, or can be manually trigged. The potential drivers are

functional, including the cathode driver, except that the target driver is being redesigned presently. Beyond this, all that remains is the interconnection of the Cohu cards to the focus and deflection coils. Lead dress may have to be refined later.

Dennis A. Kodimer

2.2 ORBIT (Project No. 15)

2.2.1 Status

The system has up to a short time ago not used the analog link between transmitter and receiver. Nine wires would transmit a digital signal directly without the D/A and A/D converter. The A/D is now being used in the system and considerable effort and time have been expended in getting the interface between the A/D converter and the receiver debugged. Several modifications in the timing and decoding cards had to be made. The first modification was done in the bandwidth selector which determines when the incoming analog signal should be sampled, and when the digitized signal is to be fed to the rest of the receiver. These timing pulses did not occur at the proper time in the original circuit causing the receiver to get improper signals that it could not interpret. Changing an asynchronous counter to a synchronous one and adding the single-shots have corrected this problem. Another problem that had to be solved was that the comparator circuitry was not fast enough to decode the successive numbers one integer apart. Failure to decode these numbers would result in termination of the decoding process for that particular horizontal line. Since the A/D converter would, at the beginning of each line, send two numbers one integer apart, no picture would be received. A faster comparator has been designed and installed and is operating correctly now. Speed was gained by using high speed logic and eliminating several levels of logic.

Another problem that was encountered and has been corrected was a jitter in the transmitter due to a reset pulse that was too narrow to be reliable. The addition of a single-shot to widen the pulse did the job.

Presently more work is being done in completely debugging the A/D receiver interface.

Peter Oberbeck

2.2.2 Receiver/Transmitter Synchronization

In order to synchronize the TV monitor in the receiver to the TV camera in the transmitter of ORBIT using a low harmonic of the transmitter clock frequency, the following system has been proposed.

The incoming signal containing the reduced bandwidth signal is applied to a narrow bandpass filter (Figure 1). The 15.75kHz signal out of the filter and wave shaper sets an R-S flipflop which is reset by a pulse that is the 600th count of the 9.45MHz clock. The output of the R-S flipflop is therefore a pulse which has a width proportional to the error in the two input frequencies. The output of the R-S flipflop triggers an analog switch which charges a capacitor for a length of time equal to the input pulse width. This voltage is fed back to the 9.45MHz clock and corrects its frequency.

To date the bandpass filter, wave shaper, 9.45MHz clock, 10 bit counter and 10 bit decoder have all been designed and tested. The most interesting circuit from the above list is the bandpass filter, and it is shown in Figure 2. The operation of this filter is simple: The twin tee network in the feedback loop acts as a low impedance to all but the frequency of interest. The theoretical Q of this circuit is approximately 23,000.

Ed Carr

2.3 Tricolor Cartograph Improvements (Project No. 16)

2.3.1 Outline Input Problem

The television camera for outline input arrived and was tested. Feeding the output of the camera directly into the logic section of the machine proved that using the television camera eliminated the nasty bleeding problem present when light pen input is used. Difficulties were encountered in making the camera compatible with the rest of the system because of delay problems. A delay circuit should solve this problem.

The final problem associated with the television camera form of outline input is that of converting the television camera output into binary (a black or a white). The television camera purchased was the cheapest camera still suitable for these purposes. But, as a result, the desired

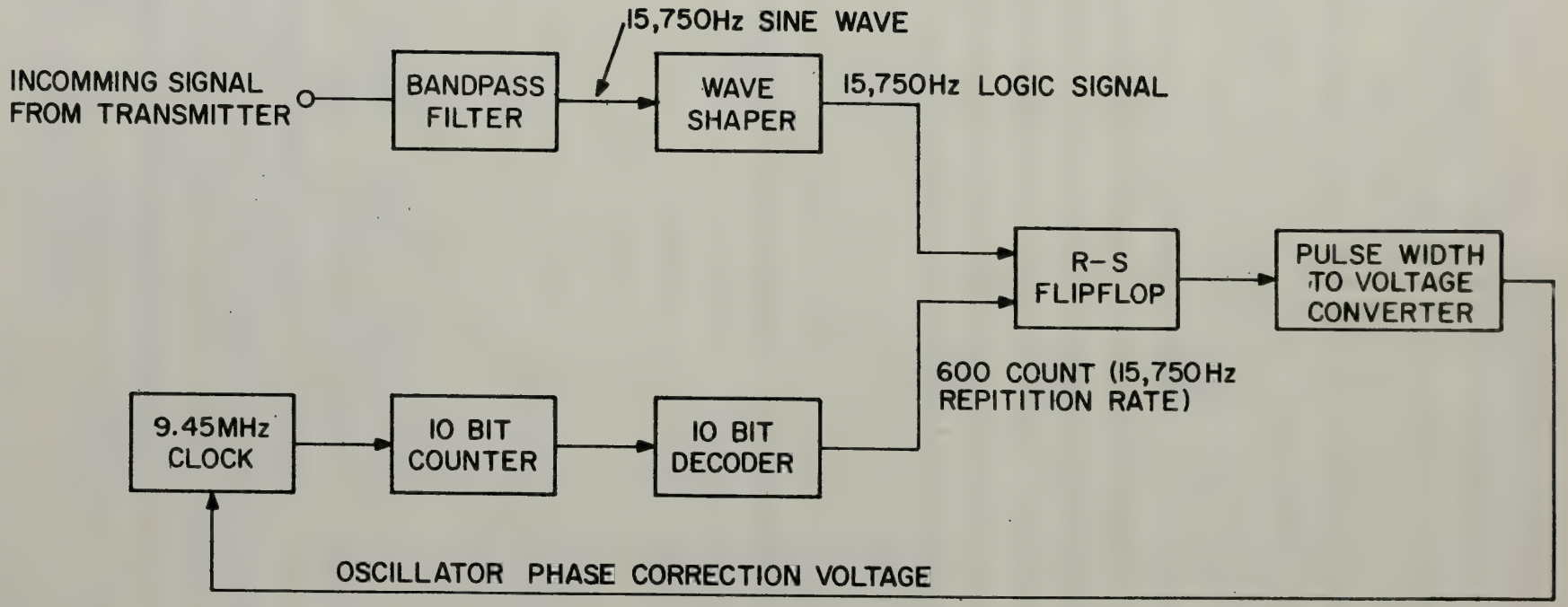

Figure 1. ORBIT Synchronization Scheme

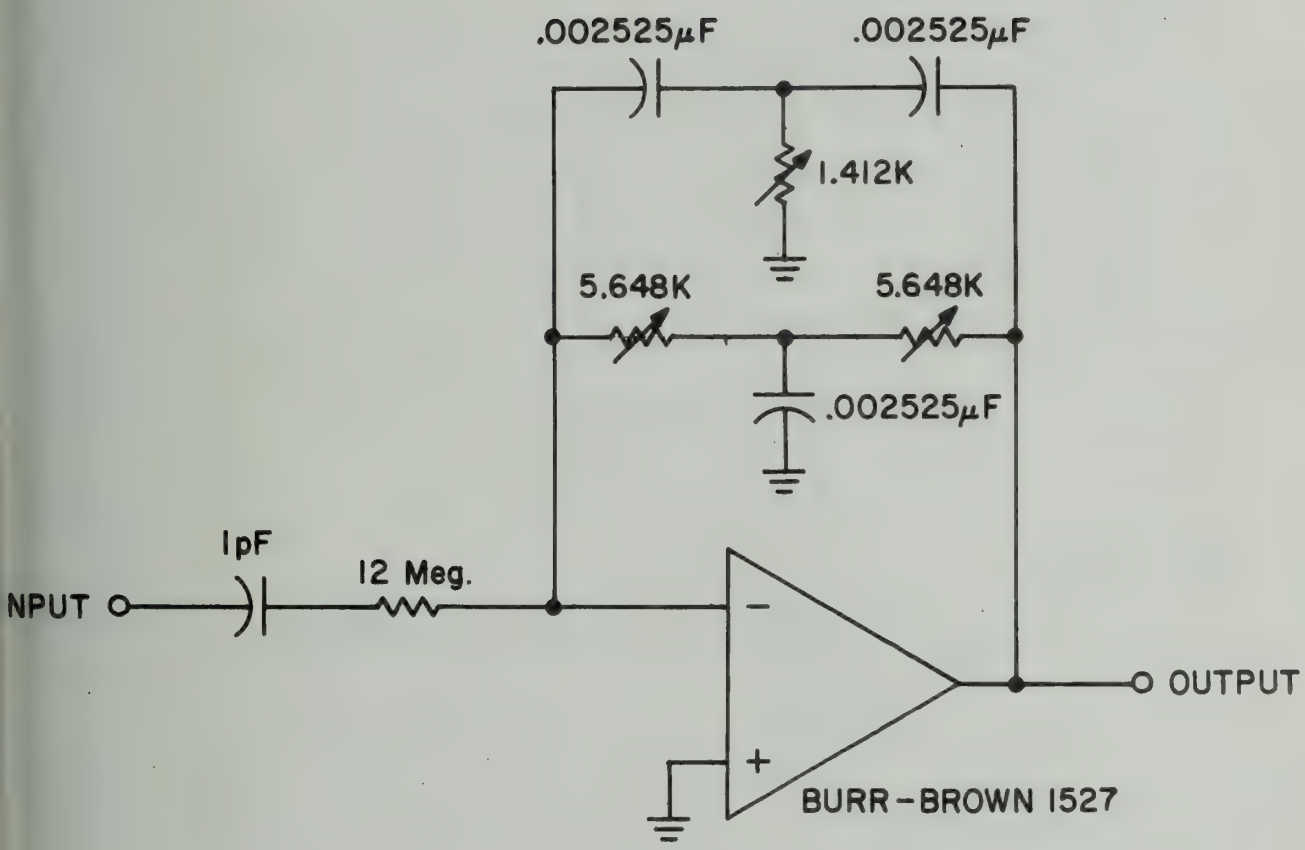

Figure 2. Bandpass Filter

signal has a parabolic base instead of a flat one due to fringe and lens effects of the camera. Theoretically, by delaying the output of the camera through one line, by also putting the camera output through a very sharp bandpass filter tuned to the parabola's frequency, and by subtracting the two waves, the desired result can be obtained with only the assumption that the parabola is essentially approximated by a sine wave. This is graphically illustrated in Figure 1.

2.3.2 Vertical Stripe Problem

The vertical color stripe problem has in essence been solved. Most of a circuit has been built which should accomplish the desired result. A full wave rectifier stage has been built using a Motorola MC1596G balanced modulator-demodulator integrated circuit. A simple low pass filter stage was added to the rectifier. The combination worked fine until the circuit was loaded. At this time, another approach is being taken to get a working, loaded low pass stage.

Don Hanson

2.4 Transformatrix (Project No. 17)

2.4.1 Determination of Ladder Resistor Values for D/A Converter

In the QTPR-JAS-1969, the circuit design of a D/A converter was described along with an equation to be used in the determination of the optimal set of resistors in the binary weighted resistor ladder. During the quarter, a computer program was written which calculates the maximum and minimum output voltages of the D/A converter for all 32 possible input combinations as a function of the five ladder resistor values, their tolerances, and the variation in the collector resistors of the hex inverter buffer. It is not necessary to include the variation of the ladder resistors with temperature since by choosing low temperature coefficient resistors (50 PPM/^{o}C for $-55^{o}C \leq T \leq +175^{o}C$) the change in resistance over the operating temperature range of the system is negligible.

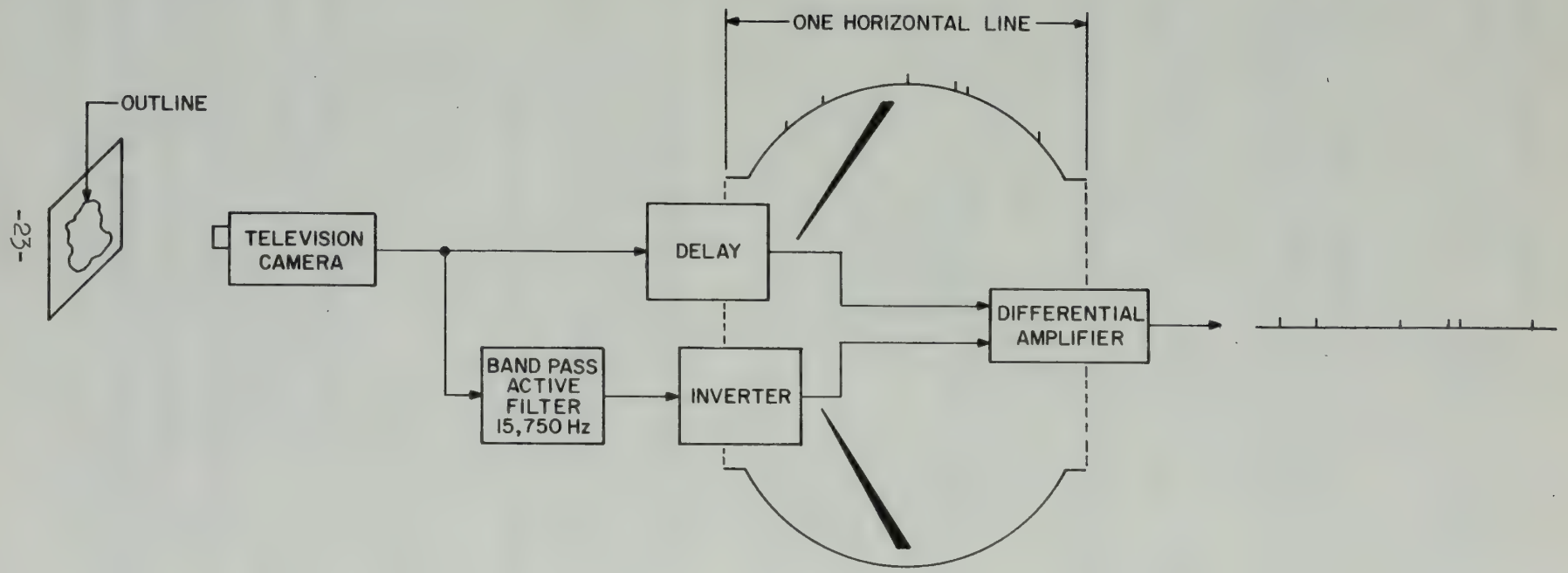

Figure 1. A Possible Circuit for Removing Video Curvature

The final set of resistor values is chosen by running the program through a range of resistor values and successively narrowing the range down around the resistor values which yield the largest difference between adjacent output voltage levels.

Although each of the five resistor values in the ladder is decremented by the same amount in the program, it was determined that the final set of resistor values results in a local maximum of

$$\alpha = 0, \overset{\text{MIN}}{\cdot\ \cdot\ \cdot}, 31 \left[V_{OUT}(\alpha + 1)\big|_{MIN} - V_{OUT}(\alpha)\big|_{MAX}\right]$$

For a design value of $R_0 = 800K\Omega$, the five ladder resistor values are:

Bit	Resistance (ohms)
0	799,696
1	399,696
2	199,696
3	99,696
4	49,696

The tolerance of all five resistors is $\pm 0.1\%$. For the above values,

$$\underset{\alpha = 0, \ldots, 31}{\overset{\text{MIN}}{}} \left[V_{OUT}(\alpha + 1)\big|_{MIN} - V_{OUT}(\alpha)\big|_{MAX}\right] = 151.1135\text{mV}$$

for a full scale reading of 5V and occurs for $\alpha = 16$.

2.4.2 Five Bit Diode Encoder

Under the Fourier Transform operation of TRANSFORMATRIX, the outputs of the 32 five bit adders (QTPR-JFM-1969) are the arguments of the cosine function. There is need for an encoder which would map the five bit argument into the cosine of the argument. The circuit for accomplishing this is shown in Figure 1. This circuitry will be contained on a single printed circuit card and has the advantage of being able to implement any many-to-one mapping simply by arranging the diode matrix in the appropriate manner.

Larry Ryan

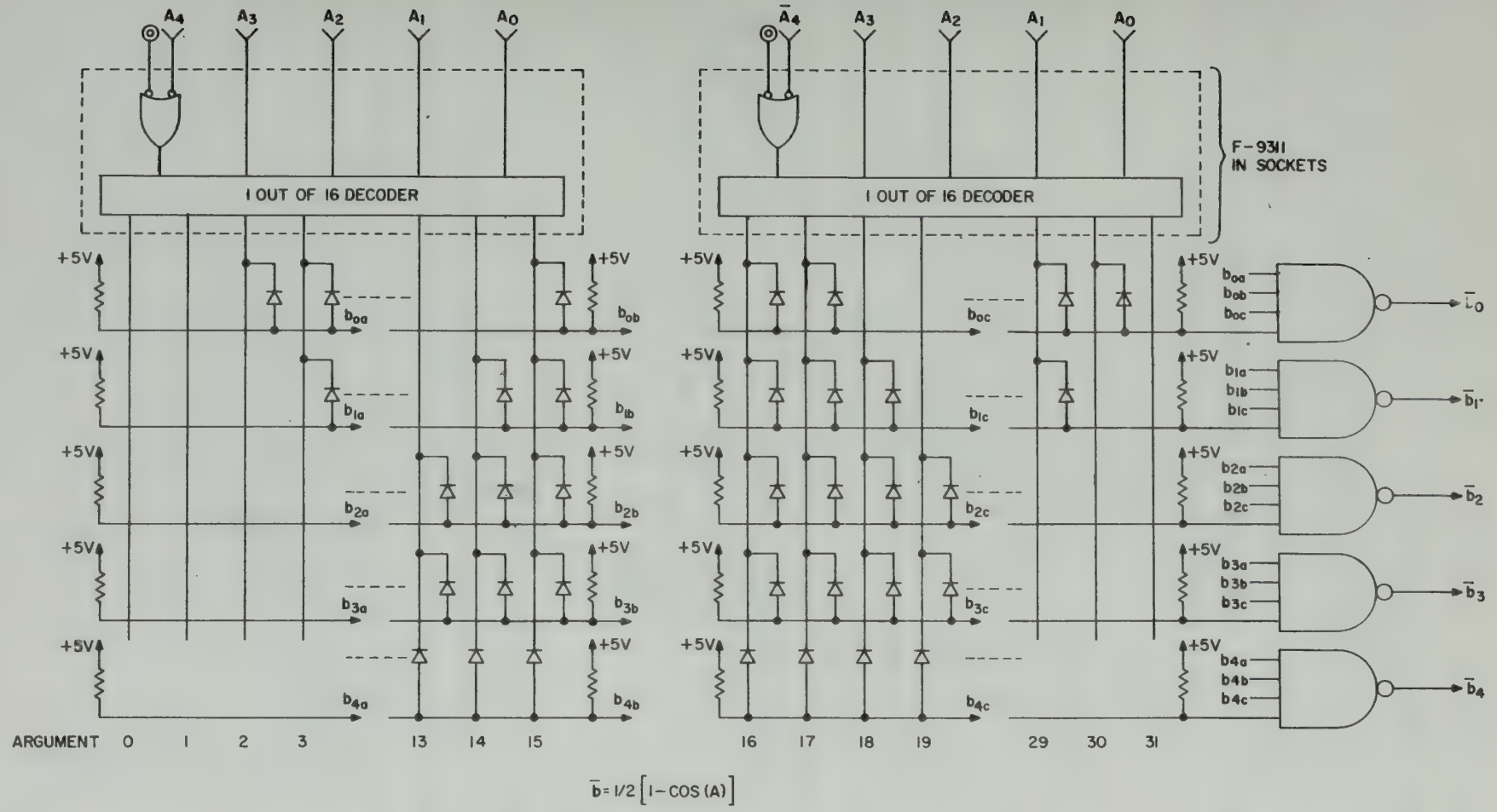

Figure 1. Five Bit Diode Encoder

2.5 BLAST (Project No. 19)

2.5.1 Video Chopper and Mixer

The video chopper and mixer circuitry has been finalized. The circuit is the same as that shown in the July, August, September 1969 QTPR except that the 390 ohm resistor at the base of the output transistor has been changed to two potentiometers in parallel in order to have a gain and level control on the output video. This is shown in Figure 1.

2.5.2 Synchronization

The synchronization of the television cameras by means of injecting a 31.5kHz pulse into the 31.5kHz oscillator in the camera was not satisfactory. This was because occasionally the oscillator would be triggered incorrectly. Also the triggering wasn't very stable at times. As a definite solution to this problem, the oscillator on the camera sync board was disconnected and a 31.5kHz signal direct from the counter replaced the output of the oscillator in driving the sync generator circuitry. A switch was installed on the front of the sync card to allow switching the sync generator back to the normal operation of using the internal oscillator. This scheme works quite well.

2.5.3 Special Cathode Ray Tube

At the end of this quarter the special cathode ray tube arrived. During the initial test of the CRT it was determined that the tube had a leak and could not be used until the leak was sealed, the vacuum reestablished, and the electron gun reactivated. This will be done shortly when the tube is returned to Electro Vision Industries in El Segundo, California

Larry Wallman

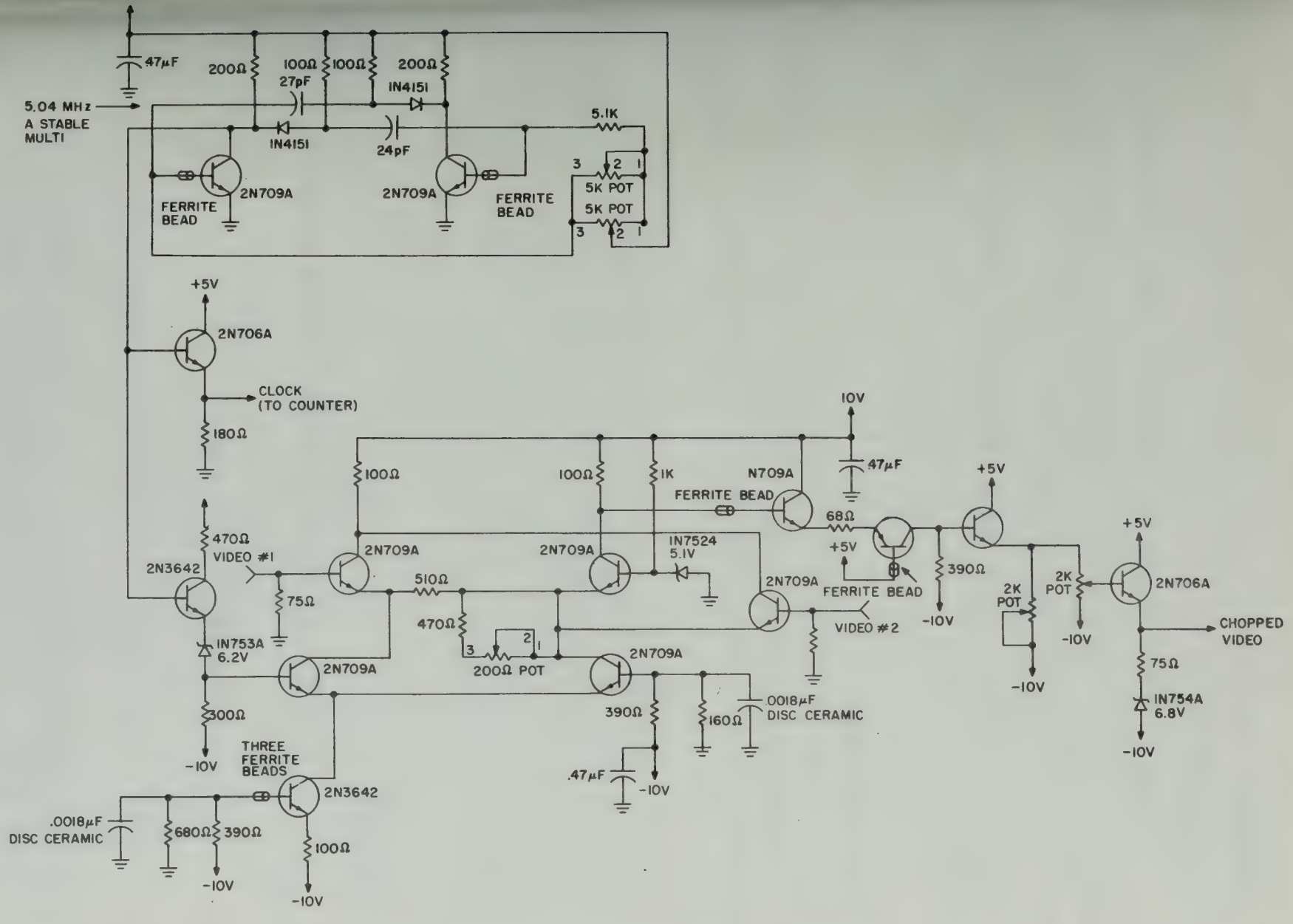

Figure 1. Video Chopper

2.6 Semantrix (Project No. 24)

2.6.1 Project Outline

Semantrix acts as a semantic jig-saw puzzle, where the adjective, "semantic", means that the strategy underlying placement of puzzle pieces is guided by the likelihood that the resultant scene could occur in "nature" rather than by the physical shape of puzzle pieces.

The strategy is derived from a "world model", and hence the resulting scene synthesized indicates the representativeness of the model.

2.6.2 Design Procedure

The project falls naturally into two parts: the world model, which will be programmed in a general purpose computer, and the hardware for communicating with the blocks. The work so far has been concerned with the latter.

The requirements of the hardware are (i) that the position and attributes of each block be communicated to the computer, and (ii) repositioning of the blocks may be accomplished upon reception of a suitable signal from the computer. Several schemes were investigated to satisfy these requirements. One of these was selected as a solution, and a sequence of experiments was devised to test its feasibility.

2.6.3 Operation

The system selected associates a number with each block; the attributes are implicit in the number, e.g.

Attribute	Block Nos.
red	[1,2,4]
green	[3,5,7]

An infra-red signal is transmitted with the block numbers encoded in the signal sequentially. The block, on the reception of its number, transmits

an ultrasonic "wave packet". The position of the block is computed from the time delay between transmitting the number and detecting the wave packet. The speed of the electronics being much higher than that of sound makes it possible to ignore the time delay associated with the electronics.

The scene is constructed by the machine, by first allowing it to choose a block at random and then complete the scene by referring to its world model for subsequent block positions. It is proposed to move the blocks by means of a miniature overhead crane under command of the computer.

A sample ultrasonic transducer has been constructed and frequency tests are being conducted to determine the characteristics of the device.

Trevor Mudge

2.7 LINDA (Project No. 28)

2.7.1 Aims of Project

The goal of project LINDA (Line Drawing Analyser) is to develop a machine which can recognize a small vocabulary of line drawings (hopefully between 50 and 200). A given pattern, such as a house, tree, car, etc. may be generated on the face of an oscilloscope. By altering the accelerating voltage of the electron beam, the pattern may be expanded or contracted. Information suitable for the recognition of some patterns may be obtained by using a ring of photo-diodes around the oscilloscope face and enlarging the pattern to the extremities. Present work is being directed at developing a pattern generator and determining to what extent the pattern vocabulary must be limited and the nature of the limiting factors.

Dick Blandford

2.8 Stereomatrix (Project No. 30)

2.8.1 Observer Position Detector

The phase detection system under consideration during this quarter consisted of a single transmitter located at the observer and two receivers at the display. The frequency was chosen such that the phase change of the

greatest expected distance from transmitter to receiver would represent less than 360 degrees. It was necessary to develop a 170MHz receiver. The receiver in its present form is a two stage, tuned R. F. transistor amplifier with the base and collector tank circuits shielded. The bias supply voltage is decoupled between stages and neutralization is provided from collector to base. The receiver is stable and has a voltage gain of eight at 170MHz. A differential amplifier in the cascode configuration is also being considered for this application. Receiver performance will be improved before the second unit is built.

A tentative phase detector design has been chosen and will be built next quarter.

Some thought will be given to using light as a carrier to reduce interference.

Chuck Pirnat

2.8.2 System Design

The instrument rack and the control desk are on order from Palatine Engineering, Inc. Power supplies for various subsystems have been received or are on order. The control of rotation and translation will be on a portable box, which is a modification of the previous design. This will enable the operator to visualize more of the stereo effect.

2.8.3 Coefficient Generator

The logic card of the final section of the coefficient generator has been made in the electronics shop, and is a universal circuit for all coefficients with a programmable capability. It is shown in Figure 1. The digital to analog converter is a 10 bit 12 channel system with its power supplies mounted on PC cards. The inverse coordinate transformer for the cursor has also been designed.

Dick Cheng

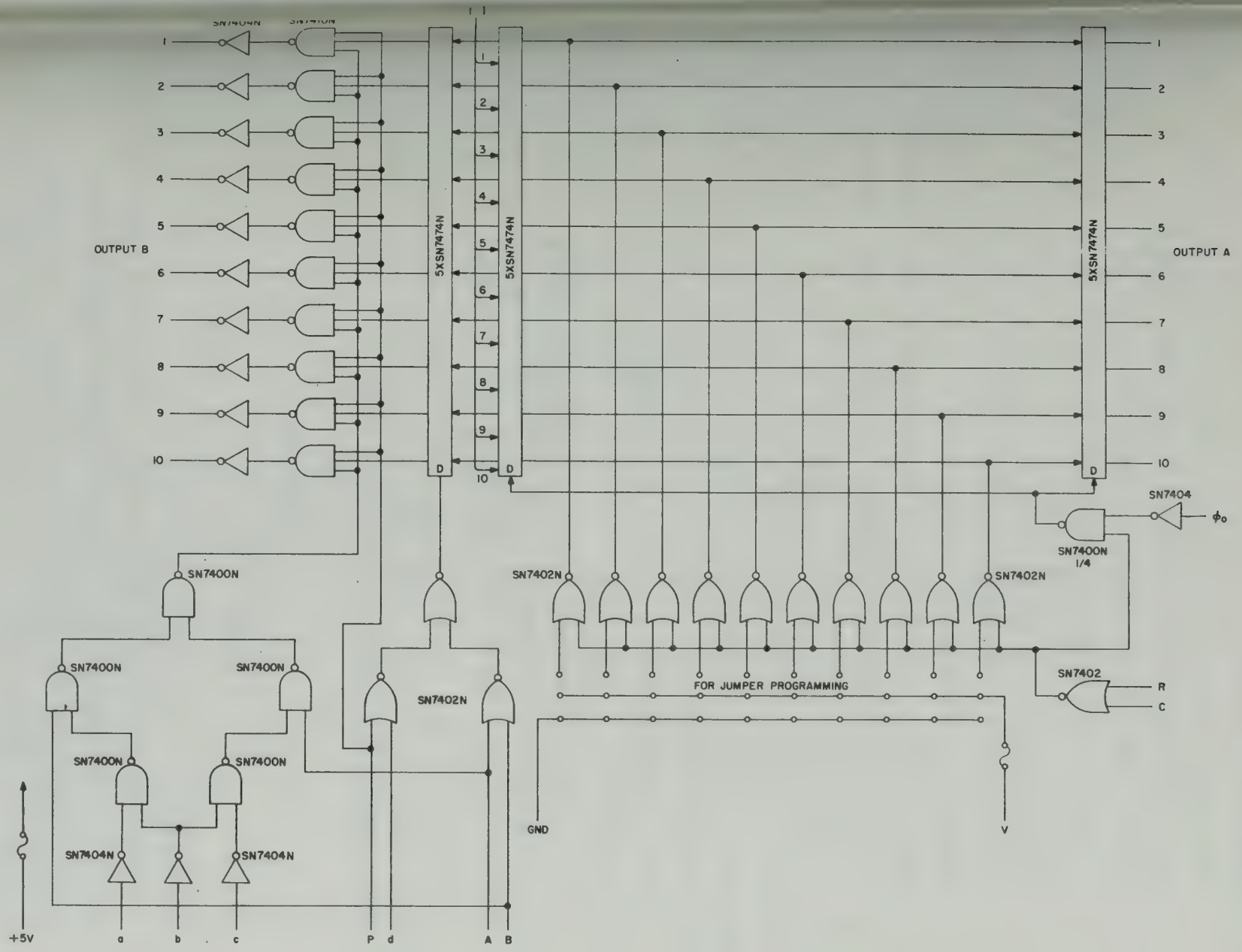

Figure 1. Output Section of a Coefficient in the Coefficient Generator

2.8.4 Stereomatrix Transformer

Stereomatrix needs about 55 analog gates which can switch ± 10 volts for the windowing unit and D/A converter. Further, these gates have to operate at a 10MHz rate. Commercially available units are both too slow and too costly, so that a fast bipolar analog gate, which works up to 10MHz and can switch ± 15 volts, has been designed and tested. The circuit for the gate is very simple (Figure 2) and has a turn on resistance of 30 ohms. There is a very good isolation between input and output. The circuit uses two junction FETs. The addition of the second FET in shunt not only insures the output is connected to ground when the gating input is zero, but also makes the fall time of the switch independent of any output load resistor. Moreover, values of capacitance C_1 and C_2 across diodes D_1 and D_2 are chosen so that the gate turn on resistance is constant for all input voltage changes in the range of ± 15 V. The turn-on and off time of the gate is limited by the transistors' (2N3905, 2N2219) switching time. The gate can be operated at speeds higher than 10MHz, if faster switching transistors are used.

This analog-gate will be used in the windowing unit as a gate and in the D/A converter.

R-2R ladder decoders have been ordered and obtained for the D/A converter. The schematic diagram of the D/A converter is shown in Figure 3. The printed circuit cards for this and the analog gate are being laid out.

In the mean time, a fast four-quadrant multiplier design has been completed and components are on order. The card layout for the other parts of the transformer is also being considered.

Shiv Verma

2.8.5 The Display

The primary effort this quarter was to get the laser operating satisfactorily. A defective laser was replaced with an improved model. Circuit modifications were then made in the power supply to allow higher power operation. Due to large pressure transients in the local water lines,

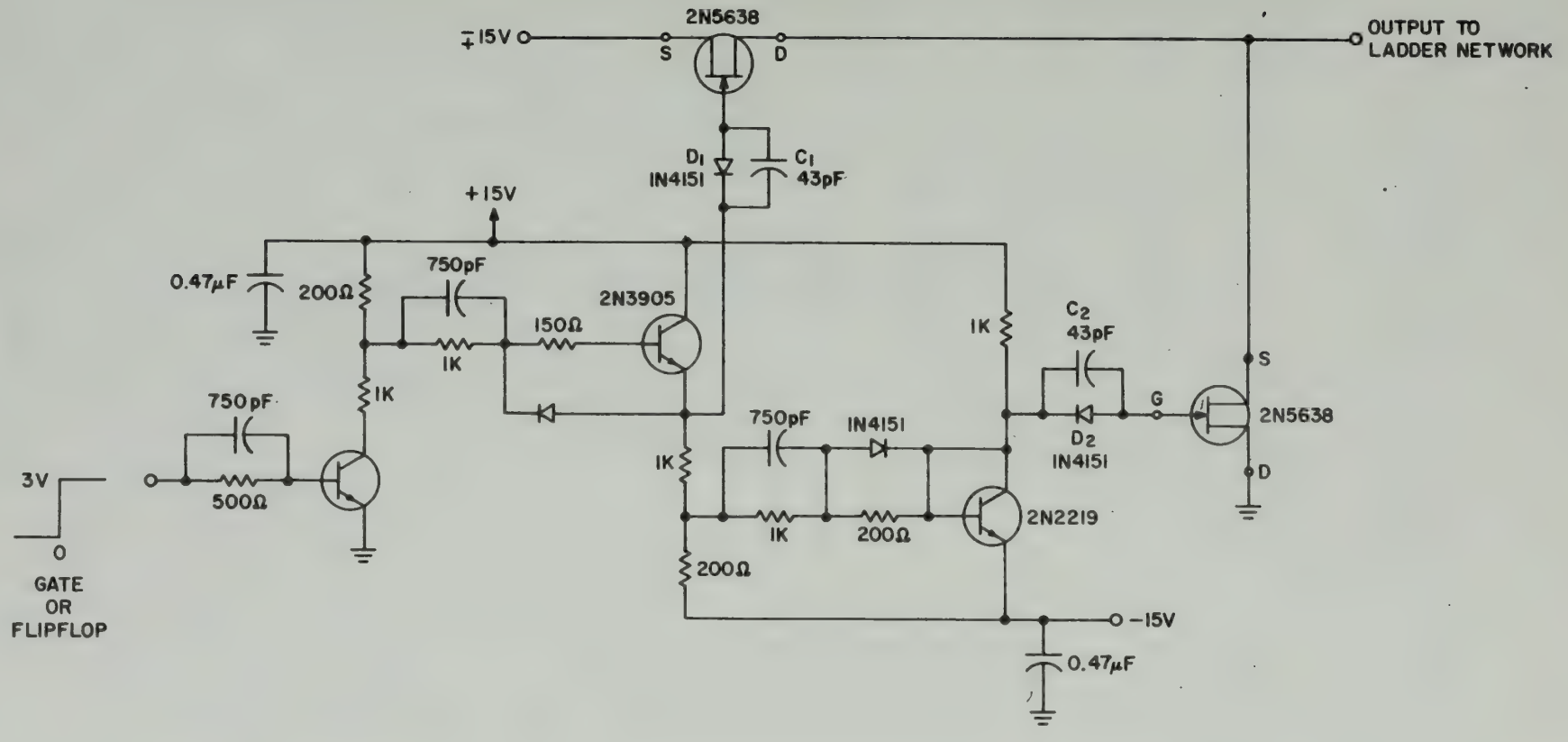

Figure 2. Fast Bipolar Gate for Stereomatrix D/A Converter

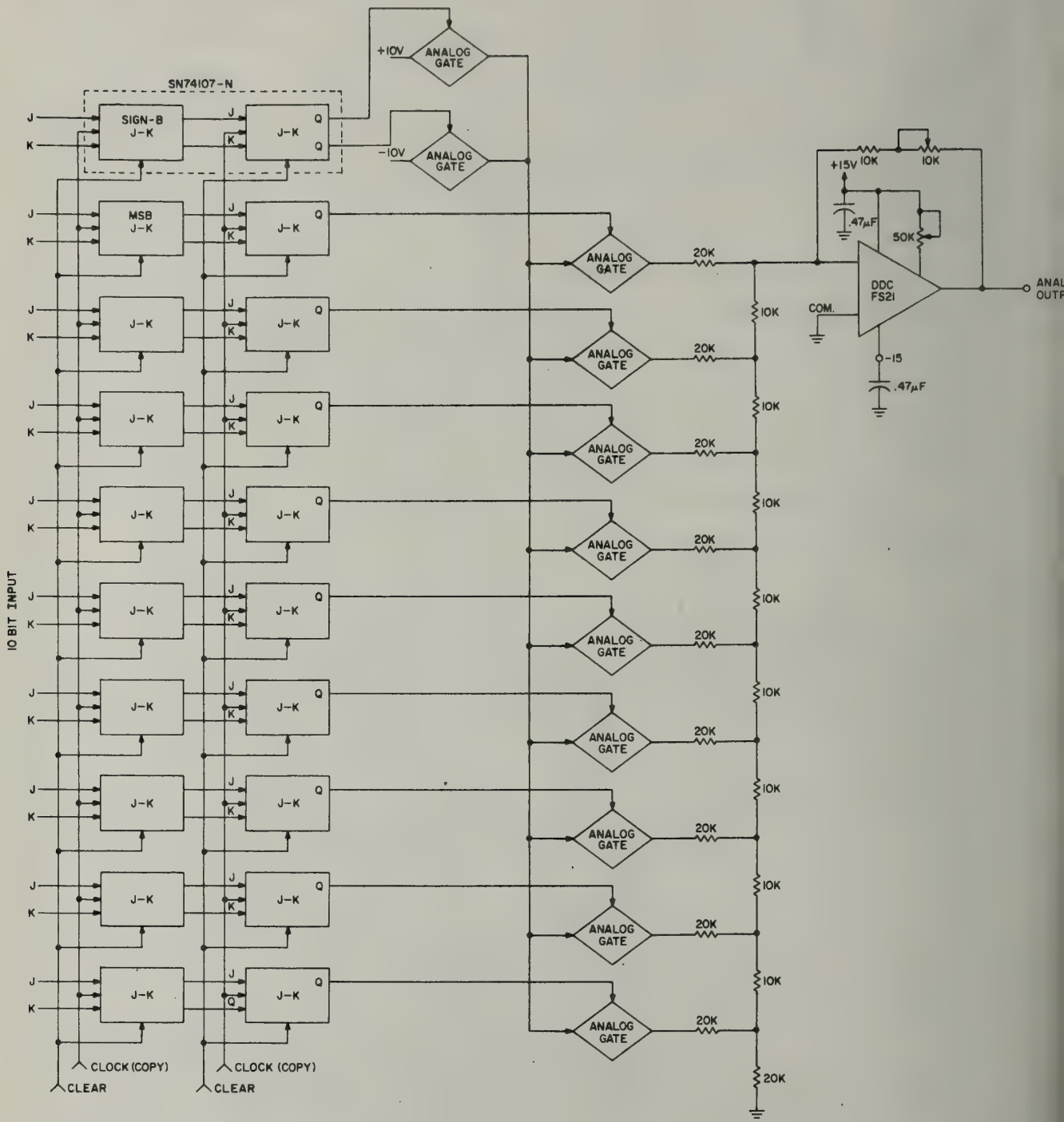

Figure 3. Fast D/A Converter

the laser cooling system will soon be connected to the closed cooling water system of the building.

Some crude measurements of the optical parts indicate losses will be greater than the first estimate of 50%. Anti-reflection coatings will be necessary.

Steve Whiteside

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3. COMPUTER SYSTEMS RESEARCH

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Reports Written

1. Carter, C. E., et. al. GRAPHICS 8, Graphics Hardware--1469-Gear, Department of Computer Science Report #371, University of Illinois, Urbana, Illinois.

2. Lopeman, H. and Miller, R. Data Disc Control, Graphics 8, Department of Computer Science File #818, University of Illinois, Urbana, Illinois.

C. W. Gear, Principle Investigator

3.1 Ordinary Differential Equations (K. Ratliff)

3.1.1 Automatic Differential Equation Solver

ODESSY Update: Version five of the ODESSY tape has been made and contains the following additions and corrections:

1. A subroutine form of the program has been added as the third file on the tape.

2. Some additions have been made to the user manual for the ODESSY program which clarify the instructions for the form of user input.

3. Corrections have been made in the Supervisor program which produce the appropriate termination of the program in case of errors in user-input initial values or in case of attempted division by zero.

4. Pass I has been corrected so that it recognizes a double precision floating point number in user input, (i.e., a constant with the exponent preceded by a "D").

5. The Integration routine has been changed since the arithmetic previously used to estimate errors for order changes was giving incorrect results due to underflow when the error estimates were very small.

Sparse Matrix Inversion: The program to invert sparse matrices is an attempt to invert these special matrices more economically while preserving their sparse quality than is done with general purpose methods. This is accomplished through analysis of the characteristics of the matrix and judicious choice of the pivot elements for Gauss elimination. The routine is to be incorporated into the differential equation package to replace the general program now used to invert the partial derivative matrix. A brief description of the method used in the sparse inversion follows.

The input matrix and its characteristics are coded in three integer arrays; MX(M,6), IROW(N,3) and ICOL(N,2) where M is the number of nonzero elements in the matrix and N is the number of rows and columns.

Table 1 shows the information which is stored in these arrays. Note that in order to conserve space the same location is used to store different types of information at different times.

Table 1

IROW(I,1)	POSITION IN MX OF ELEMENT BEGINNING ROW I.
IROW(I,2)	NUMBER OF NONZERO ELEMENTS IN ROW I.
IROW(I,3)	THIS ELEMENT IS ZERO IF THE RIGHTHAND SIDE OF THE EQUATION REPRESENTED BY ROW I IS ZERO.
ICOL(I,1)	POSITION IN MX OF ELEMENT BEGINNING COLUMN I.
ICOL(I,2)	NUMBER OF NONZERO ELEMENTS IN COLUMN I OR THE NEGATIVE OF A POINTER TO THE BEGINNING OF A CHAIN OF ELIMINATED ELEMENTS IN COLUMN I.
MX(I,1)	THE TYPE OF THE Ith ELEMENT (1=INTEGER, 2=CONSTANT, 3=SYMBOLIC EXPRESSION) OR POINTER INDICATING THE NEXT ELEMENT IN A CHAIN OF POTENTIAL PIVOT ELEMENTS.
MX(I,2)	ROW NUMBER OF ELEMENT (NEGATIVE IF ROW HAS BEEN PIVOTED).
MX(I,3)	COLUMN NUMBER OF ELEMENT
MX(I,4)	POSITION OF NEXT ELEMENT IN ROW (ZERO IF LAST ELEMENT) OR FORWARD PIVOT CHAIN POINTER.
MX(I,5)	POSITION OF NEXT ELEMENT IN COLUMN (ZERO IF LAST ELEMENT) OR BACKWARD PIVOT CHAIN POINTER OR ELIMINATED ELEMENT CHAIN POINTER.
MX(I,6)	LOCATION IN FLOATING POINT ARRAY OF THE NUMERICAL VALUE OF ELEMENT I OR NUMERICAL VALUE OF Ith ELEMENT IF TYPE = 1.

The steps in the pivot selection algorithm are as follows.

1. A subset of the columns is chosen {C} which contains those columns with the minimum number of nonzero elements which have not been chosen previously as pivot columns.

2. All elements in the columns {C} are compared according to the number of nonzero elements in their respective rows, eliminating those in rows already chosen as pivot rows. In this step the type of the element is also taken into consideration with preference for the simpler type. The result of this step is a chain of potential pivot elements.

3. A pivot is chosen favoring elements whose rows have a right-hand side equal to zero. Information in the various arrays is then updated or restored where necessary. This includes recording the steps in the elimination relating to this pivot, and then actually carrying out the arithmetic involved.

4. Steps one through three are then repeated until all pivots have been chosen at which point the back substitution process is performed to complete the inversion process.

The result is not the inverted matrix itself, but the effect of the inverse on another matrix.

3.2 Graphics

3.2.1 Disk Monitor System (H. Levin)

The PDP-8 now has a fully debugged, operational monitor system running on the disk. At the heart of the system is Digital Equipment Corporation's "Disk Monitor System" (see DEC NO DEC-D8-SDAB-D). Modifications were written to accomplish the following:

1. Adopt DEC's software to work with the disk that is currently on the machine (not supplied by DEC).

2. Allow users to save disk images on a Dectape, and then reload the disk from these tapes at a later date.

3. Enable DEC programs to take advantage of the new high speed Inktronic printer that was installed on the machine.

New programs that were written for the system include:

1. SWAP: Loads up disk from tape.

2. EXIT: Loads up tape from disk.

3. RECOVR: Restores disk system from tape system.

4. RCVR: Returns to tape system from disk.

5. LIST: Lists ASCII files from the disk on either the Inktronic printer or the TTY. (R. Haskin)

6. SEND: Sends ASCII files from the disk to timesharing. (R. Haskin)

Users of the new system have reported a considerable speed-up in program preparation, debugging, and loading as compared to the old Dectape system. For example, a 4k disk program can be loaded into core in about two seconds, as compared to anywhere from twenty to ninety seconds for the Dectape system. Program assembly has shown an even larger speed-up.

Current work on the system includes modifications to the assembler to produce better listings, and the development of a general purpose copy program to facilitate conversion from the old Dectape system to the new Disk system. This phase of the work is being done by Roger Haskin.

A user's manual has not yet been written, so interested users are encouraged to contact Harold Levin for additional information on using the system.

3.2.2 338 Software (C. Hyde)

Work was nearly completed on two sections of the drawing routine package. The subroutine which performs updates on a line drawing and its corresponding control section in the FLOG program was written and debugged. A subroutine to add previously defined elements to the current picture was written but not debugged, and is currently being rewritten in an attempt to eliminate problems encountered in the first version.

A tentative allocation of storage in memory banks 0 and 1 was also completed. A method of allocating variable length blocks of memory in bank 0 for specific use by the drawing routine package was devised and implemented.

The interface to the PDP-8 system (GLASP) was completed, and the interface to the information retrieval system was partially specified.

3.2.3 Disk Hardware (C. Hyde, H. Levin)

A new disk interface is currently being constructed. The present interface suffers from the following disadvantages:

1. The error rate on writing is approximately 50% which implies rereading of all data with software checksums to insure data integrity.

2. The sector length of 1360_{10} words is clumsy on a machine where the natural unit of information is typically 128 words. This sector size forces buffering which wastes both time and space.

The new interface will include a hardware parity bit on each word to guard against errors. The instruction set will be transparent to tracks and sectors, and will typically request M words starting at word N, where $1 \leq M \leq 8192$ and $0 \leq N \leq 294{,}911$.

3.2.4 Graphics Monitor (M. Michel)

The 2701-PDA high speed data link connecting the service area 360/75 system and our PDP-8 has finally arrived and has been installed. The hardware interfaces and the link have been tested, and 128 word (12 bit) blocks can be successfully transmitted in both directions. However, to better meet the requirements of the simulation system, we have decided that variable length block transmission rather than fixed length block transmission is desirable. Very often, but not always, long logical blocks of data must be transmitted. Sending a series of many short, standard length blocks would mean an unreasonable amount of overhead due to the IBM operating system. Hence, the PDP-8 interface to the 2701 has had a 12 bit word counter added to it, enabling continuous transmission of 1 to 4096 words (a full PDP-8 core bank). This capability, in turn, has required some software changes in both the /360 monitor (GASP) and the PDP-8 monitor (GLASP). Specifically, the buffering problem is acute: neither end of the software knows how long an incoming record is until it has been read-in.

One solution is to maintain a maximum length buffer at all times, but that would mean saving an entire PDP-8 core bank on disk whenever a 2701 record is to be received, even though the input might turn out to be short. Also, since a bank of PDP-8 words fills 8192 (3.g. 8K) /360 bytes, space in the 75 would be eaten at a high rate, particularly in the case of maintaining several tasks, each communicating with a PDP-8 graphics console. The compromise arrived at entails transmission of standard length (128 words) block followed immediately by a variable length ("extension") block; a word count n of the total amount of data is contained in the first block. If $n \leq 125$ (control information plus the count requires three PDP-8 words, making the maximum

data in the first record = 125), there will not be an extension block at all and only the first n data words of the standard block are valid. For n > 125, there will be an extension block of length n - 125 words to be concatenated to the data already received. The control information in the first record specifies which console the record applies to and what type of data it contains (I.R., data structure, display file, etc.). Hence, only short buffers need to be kept permanently, since the monitors can determine how large the data block is and what is to be done with it before the main chunk arrives. Modifications to the buffering system and user macros in GASP have not yet been completed; however, GLASP is being implemented in its initial form using the above method of 2701 data handling.

The GLASP monitor for the PDP-8 supports up to 8 interactive graphics terminals with the possibility of different data, pictures, and programs servicing any particular terminal. Basically, GLASP

1. Routes user console interrupts to the appropriate "program" subroutine for each terminal, and
2. Schedules all requests for access to various system devices (disk, 2701, DPU, Inktronic printer, TTY, etc.), and services (Information Retrieval, bank swapping, picture regeneration, etc.)

Each terminal is associated with a fixed, 64-word area of storage called a console vector (c.f. Figure 1). The Head (first 14) words) of the vector plus the first 4 words of the "Tail" are used by GLASP; the Tail is available to any "program" running under GLASP. A console vector completely specifies the current status and subsequent activity of its terminal. The Head contains "program" restart data bank control information, parameter list space, and user identification. The first four words of the Tail contain the addresses of routines to handle the four possible user console interrupts (joystick hit, manual interrupt, pushbutton, keyboard). The rest of the Tail is used by any particular "program" to store intermediate data, flags, parameters, etc. Hence, all "programs" are serially reusable: the same "program" can be used concurrently on one to eight terminals, since the "program's" data is stored in the console vector for each terminal that it is assigned to. Core banks 0 and 1 of the PDP-8 contain a data structure and

display file, respectively, for the terminal being serviced. A data tructure and display file manager is resident in bank 2; GLASP, "programs", nd the IR routines are in bank 3 (c.f. Figure 2 and Figure 3). To take rather circuitous path for descriptive reasons: a picture is generated n the CRT face of a console by incremental data on the disk. The ncremental data is produced by the DPU from a display file in bank 1. ne display file in bank 1 is constructed by the display file manager in ank 2 from the data structure in bank 0. The data structure in bank 0 s altered and manipulated by the data structure manager in bank 2. And ne various functions of the managers in bank 2 are requested by programs" resident in bank 3.

Following events along a different path: a console user causes n interrupt (e.g. a pushbutton hit). The GLASP interrupt handler etermines that the interrupt was from a console, fetches the console umber, and determines that the interrupt was caused by a pushbutton. ne interrupt handler accesses the appropriate console vector, obtains ne address of the desired "program" pushbutton hit routine, and jumps o that routine. (If the routine was not in bank 3 at the time, a riority disk call would have been used to load it into the "program" ransient area.) This "program" subroutine can now change the console ctor (flags, parameters, routine addresses, etc., i.e., change the state f the console vector in anticipation of subsequent user interrupts); ll the managers to alter the data structure, display file, and screen nage; call I.R. for subpictures; request 2701 data transmission; etc. ntrol is then returned to GLASP via a WAIT routine. Clearly, GLASP, .R., the managers, the device routines, etc., from a control and utility stem, while the "programs" provide the response sequences to user rvice requests (i.e., interrupts). Hence, for any application, the riable sections of code (the only sections of code that need be changed) e the "programs." Change the "program" and obtain a generalized rtwork drawing program, a text editor, a library inquiry station, an gebraic manipulator, a graphical compiler, etc.

After being entered via the GLASP interrupt handler, a "Program" interracts with the system by calling a combination of three routines (RØUTX, RELESE, WAIT) and by manipulating the console vector Head. If an interrupt requires only alteration of information in the console vector, a direct return to WAIT is taken. If the data structure or display file must be altered or if some system service is required, the "Program" sets a parameter list and a request number into the Head and goes to RØUTX. This routine schedules all service requests and controls banks 0 and 1 core allocation. (Since only one termina's data structure and display file can occupy banks 0 and 1 at any given time, this routine is clearly responsible for task switching, bank swapping, resource allocation, request queuing, etc.). After RØUTX determines that the request can be filled (e.g. banks 0 and 1 have been filled with the appropriate data structure and display file and the desired service is NOT already busy), RØUTX calls the required service routine and passes it the address of the requesting console vector. The service routine marks itself busy, obtains its data from the parameter list in the Head, and begins executing. If it must receive interrupts from a device (e.g. disk, 2701, DPU, TTY, etc.), the routine sets its interrupt entry address into the appropriate word of the interrupt handler and jumps to WAIT. When the service routine completes its processing, it clears its busy flag and goes to ØPDØNE. This system routine returns control to the "Program" that initiated the service request. When the "Program" has completed its processing, it indicates which of its banks are to be saved (if any) and jumps to RELESE. RELESE saves the desired banks, terminates processing of the particular console and then scans for queued service requests from other consoles. If such a request is found, control is returned to RØUTX; else, control is passed to WAIT. WAIT always tests a series of priority flags before actually "waiting" for a new interrupt. Hence, certain system requests (disk access for bank swapping, I.R., 2701 transmission requests, etc.) can be given priority status over "Program" requests.

The system is being implemented in two versions. One assumes a DPU with eight attached consoles (each with joystick, pushbuttons, manual interrupt button, and keyboard), a disk, 2701 link, Inktronic printer, clock, and a TTY/Keyboard as an operator's station. The second is identical to the first except that the interrupt handler has provision for a 338 display controller to simulate the DPU with one attached console. This is a "prototype" version until the DPU is completed and until the exact configuration of the individual consoles is settled. A mouse, joystick, and data tablet can be used interchangeably with the display in this version.

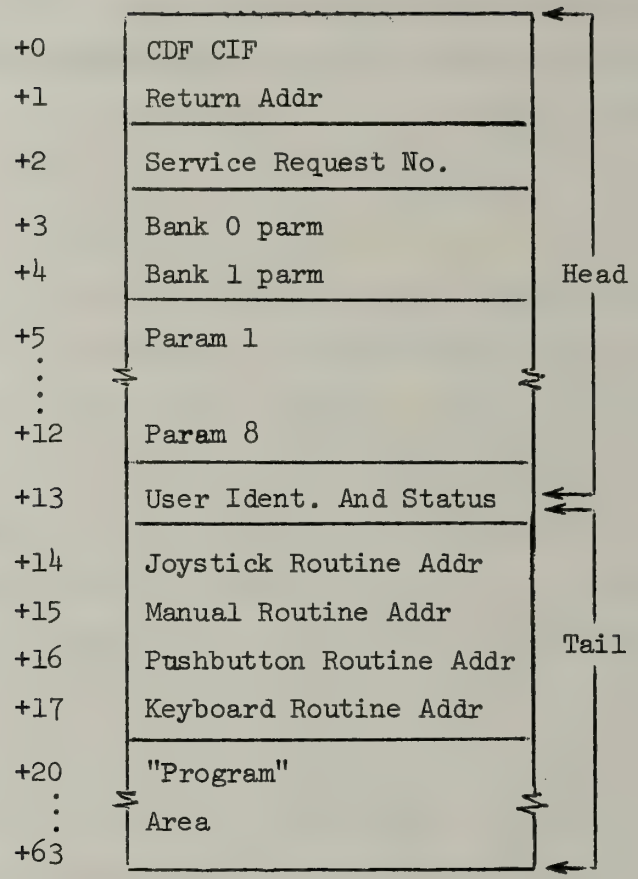


Figure 1

Console Vector (Head Detail)

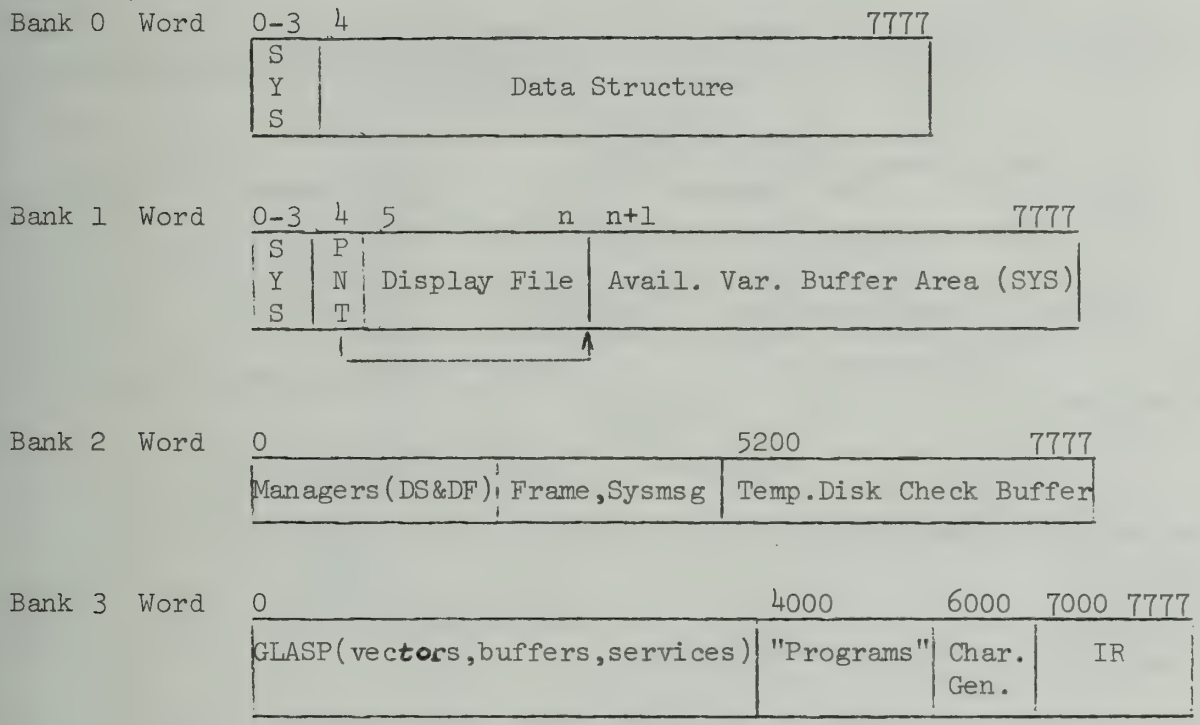


Figure 2

Core Allocation

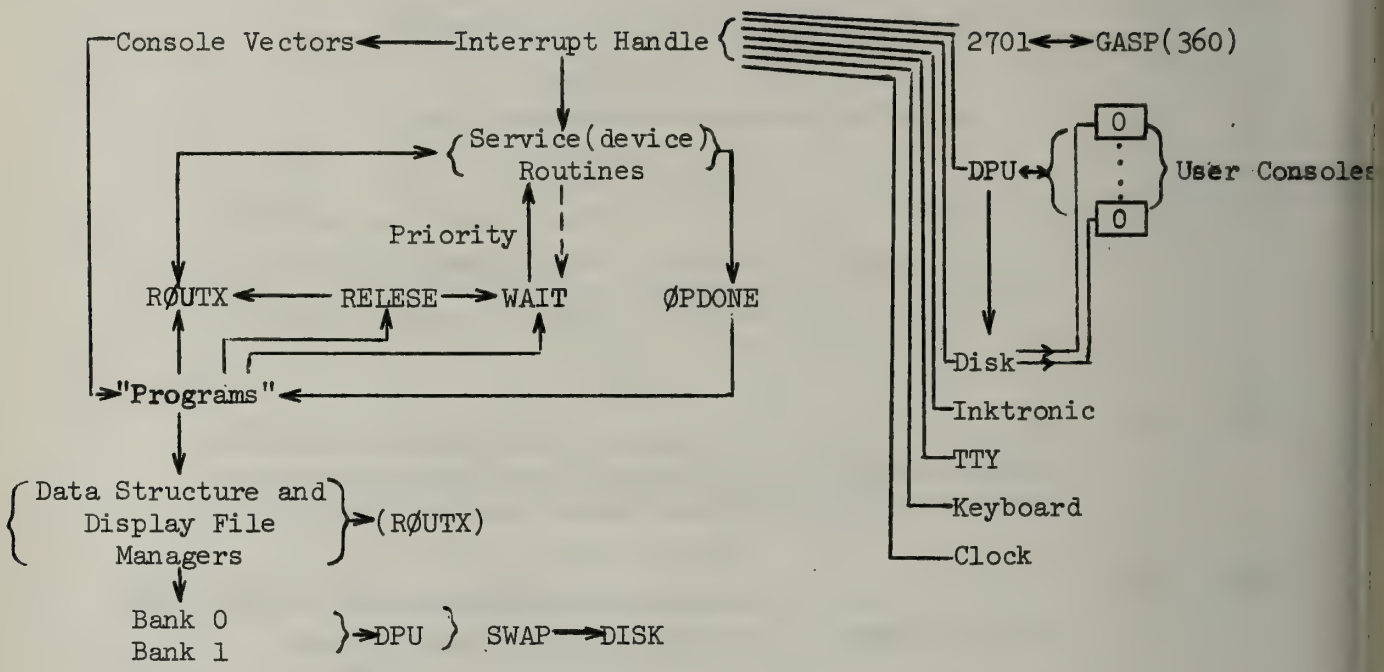


Figure 3

Control Paths

3.2.5 Graphics Display Language (J. Roman)

Two new versions of GDL were written and initially tested this quarter. One, an intermediate version, is identical to batch GDL, except that statements are completely processed as each is read--a semi-interactive mode. This version was basically a test and debugging tool for the other new version, a fully interactive graphics version. The graphics version runs in a 360 region under the GASP monitor and interacts with a PDP-8 user. Statements are entered on the teletype keyboard; error messages are returned on the teletype; and "draw" statements result in an image on the 338 CRT.

Unfortunately, this new GDL uses the PDP-7/630 link and old software which is being replaced by the 2701 and new software. Fortunately, the I/Ø sections needed are not too extensive and can be rewritten in the new software fairly easily. This will be attempted in the coming quarter along with final testing of the new GDL.

3.2.6 Item and Global Analyses (S. Wilkins)

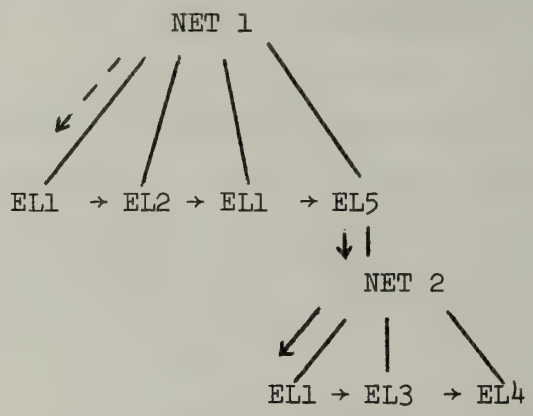
The first step in the analysis of a network is the production of a system of equations that is equivalent to the network. This step can be divided into two algorithms.

Algorithm I: This procedure will be called the item analysis. The main function will be to produce a table of all the information pertinent to the user's network. The table will occupy sequential words in core since its size is not anticipated to change during the network analysis. The table will contain

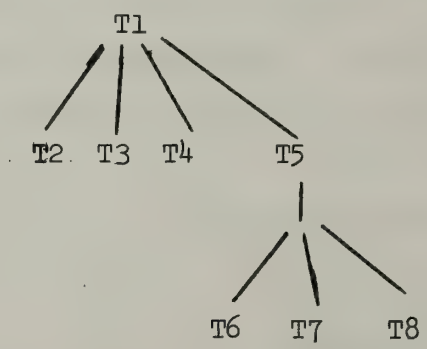
1. Terminal type information
2. Element descriptions
3. Network descriptions.

The design of the table will emphasize ease of access of any item of information. Base addresses and pointers relative to these will provide quick indexing.

Algorithm II: This procedure will be called the "global-analysis." The purpose is to produce a system of equations that is equivalent to the network. The general procedure is to begin with the network and work down to the elements comprising the network. Every element instance that occurs in the network must be analyzed since each instance will produce a set of equations. Careful consideration must be given at all times to the scope of the variables used. Tables of global and local variables are maintained. The analysis for the network below



would follow the order NET 1, EL1, EL2, EL1, EL5, NET 2, EL1, EL3, EL4. The local variables would be kept in a tree structure corresponding to the structure of the analysis tree so that local variables are available only to elements at a lower level on the same branch.



A detailed description of the table structure and Algorithm II will be published by the Department of Computer Science in the near future. An example is introduced and followed in detail from the data structure output of Algorithm I to the system of equations generated by Algorithm II.

3.3 PLORTS Timesharing System (A. Whaley, J. Christopher, P. Boekhoff, G. Eitzen, P. Zima)

3.3.1 Maintenance

The paper tape punch on the PDP-7 developed a very elusive error, such that it became impossible to keep the timesharing interface program in this medium. A method for loading the PDP-7 from the 360 has now been successfully implemented. True to form, however, the new system was the first to have serious trouble with errors in the PDP-7 to 360 channel.

3.3.2 PL/I System Supervisor

The PL/I interpreter has been underway for some time now, but it has been lacking a system to run under. This quarter such a system was begun and completed. It is a table driven supervisor which multiprograms any number of users, and handles communications between the reentrant PL/I system and both the file structure and any number of outside communications devices. At the moment, outside devices consist of one PDP-7, but the graphics system under development may be included at a later date.

The PDP-7 interface is extremely complex; one of its features is the stacking of input and output. It is anticipated that this will greatly increase console response time by overlapping computation and typing by both the user and the computer.

The new supervisor has been debugged and extended so that it will also run in a batch environment.

A modified version of the filing system was required for the new supervisor just mentioned. Two new features were added when the modifications were installed. Checking of user disk space allotment was implemented (on a dynamic basis). Also, a previously provided for change was made to greatly reduce the time required to locate a record in a file.

3.3.3 Pass I

Using the batch version of the PL/I supervisor mentioned above, debugging of Pass I has proceeded well and appears to be mostly finished. The most difficult area left to be handled is the declare statement. Pass I output has been carefully scrutinized by hand and appears to be ready for Pass II.

3.3.4 Pass II

The statement recognizers were coded this summer using IBM calling sequence conventions. It was decided that the response time might approach the age of the universe; these conventions are therefore being discarded in favor of a sensible method. At the same time, the necessary driver is being added which reads Pass I output and invokes the appropriate statement recognizer. These changes have not been completed, but Pass II should be ready for debugging shortly.

3.3.5 Pass III

Pass III is finally past the stage of implementing the arithmetic and Boolean operators, which have now been coded. The internal loop controls for array handling in assignment statements (discussed in theory in an earlier report) have also been coded. The details of storage management and subroutine initialization have been worked out and are being programmed now.

Two design changes of significance have been made. The first, that all floating-point arithmetic is to be double precision, has already been noted. The second is that the POINT operator, which points a dummy parameter to the corresponding actual parameter, is now an infix operator as the result of the recent discovery of lock-ahead problems. Thus, the Pass II PROCEDURE output code listed in the last QPR's discussion of parameters must be changed from

Pop	3	Verify	C	Point	B	Point	A	Point

to

Pop	3	Verify	Point	C	Point	B	Point	A

Pass III coding is well underway. Several large holes remain:

1. Initialization; which will be partly redefined as coding progresses.

2. Input output (partly written).

3. Complex arithmetic; this should be fairly easy to "bolt on" without extensive revision.

4. Nonfatal error routine; this should be as sophisticated as is feasible with the ability for the user to tell the system how to recover.

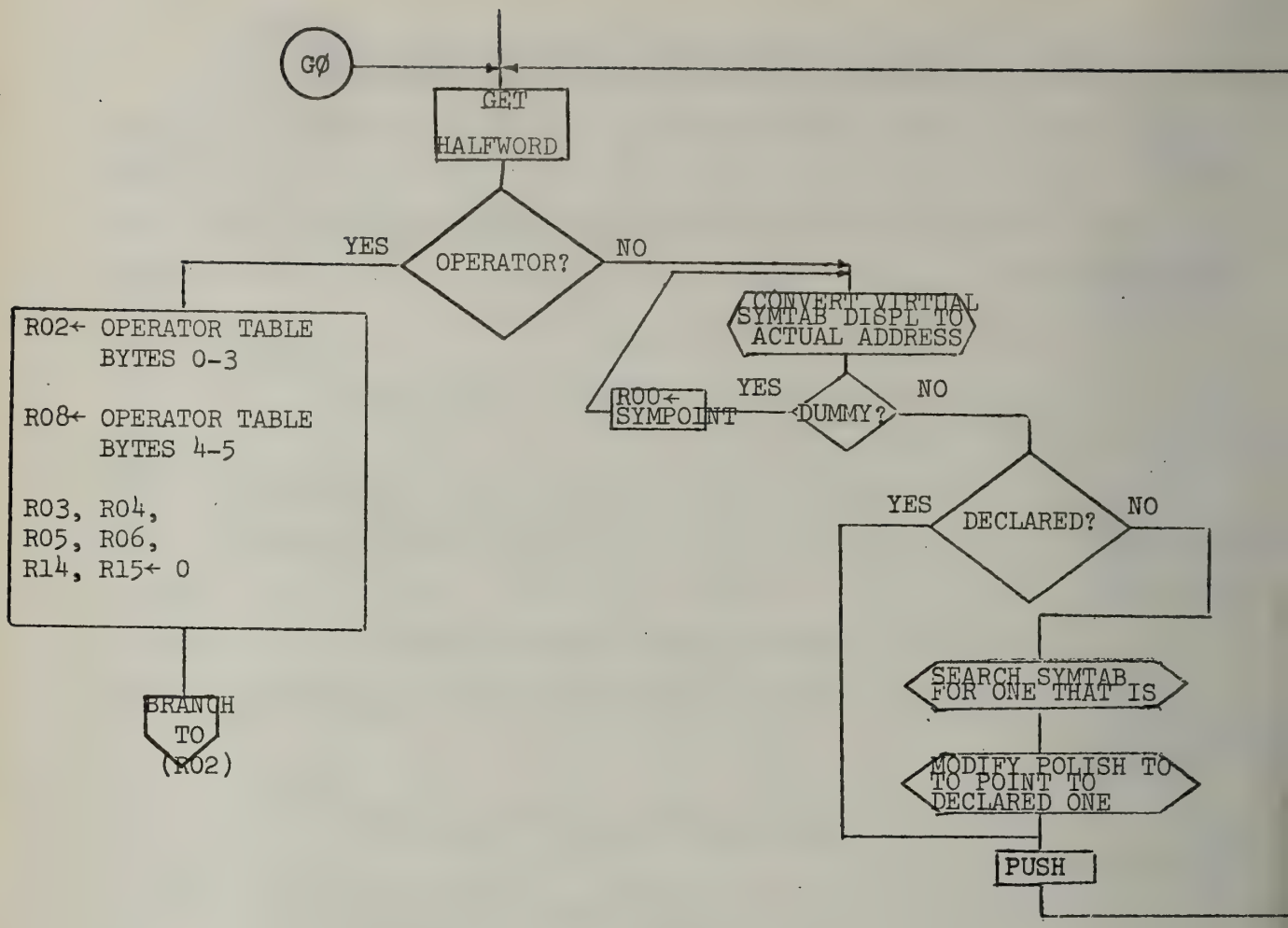
5. Termination, including fatal error routine.

6. Routine to get the next polish halfword; this will have to be tied in with

7. Routine to modify the polish string when a symbol is resolved, and

8. Branch routines, to reset the polish location counter.

The basic Pass III flow is as follows:



This is roughly the logic of a "typical" binary operator:

1. Retrieves both operands from the stack.

2. Perform any necessary type conversions.

3. Perform the operation, leaving the result.

4. Generate the top four SYMTAB bytes corresponding to the result.

5. Pop the two operands.

6. Move the results symbol table entry into the first available slot in the pseudo symbol table.

7. Push a pointer to this PST slot and exit.

Accordingly, the following subroutines now exist:

PUSH

The stack is built "backwards" in core; each new element is one word lower in core than its predecessor. This allows a binary operator to find both its operands using the stack pointer as a base register. Each entry in the stack is a fullword address pointing to the symbol table (SYMTAB) or pseudo symbol table (PST) entry for the operand.

PØP1

An operator may exit through POP1, which pops one entry from the stack on the way out.

PØP2

This pops two entries out and branches to GØ.

JUS1

This routine picks up the top stack entry (pointed to by STK), picks up the first four SYMTAB bytes from the SYMTAB (or PST) entry and puts them into SVDATA1, and moves the data pointed to by the SYMTAB/PST entry into SVNUM1, then returns to the caller.

BOTH

This routine picks up the second operand in the stack, fills SVSYMPT2,SVDATA2, and SVNUM2 as above, then branches to JUS1 to get the first operand and return.

XBIT

This routine is entered with register 1 pointing to SVDATA1 or SVDATA2. It converts the value in SVNUM1 or SVNUM2 to a bit string placing the result in SVNUM1 or SVNUM2. The length of the string is unchanged if the argument was a bit string or a character string. If the argument is fixed, the length of the result is 31; floating, 53. XBIT then returns to the caller.

XCHR

This is the character equivalent of XBIT. It leaves the length unchanged for bit or character. If the argument is fixed, the length of the result is 14; floating, 22.

XFIX

XFIX converts the argument to BIN FIXED and returns.

XFLT

XFLT converts the argument to BIN FLOAT and returns.

PUSHNUM1

This routine finds a slot in the PST for SVDATA1 and SVNUM1. If there is no room in the current PST segment, another is created; all but the first segment will be freed at EOS. SVDATA1 is moved to SYMENTRY, SYMPOINT is set to X'FFFF', and SVNUM1 is moved to SYMDATA. Register 1, which points to this new entry, now has its first bit turned on, and the routine branches to PUSH.

The following operator routines have not been written:

Branch
BT/BF
RETURN/RETVAL
Temporary generator
Allocate
Set flush list pointer
I sub
LREP/RREP (DCL replication)
OPEN/CLOSE
GETEDIT/PUTEDIT/GET LIST/PUT LIST
FORMAT routines

The following are a few of the operator routines which have been written. In general, the routine name corresponds to the operator name with the prefix EX instead of OP. Thus, if the scan finds OPPOINT in the polish code, it branches to EXPOINT. Exceptions: all compare operators (OPEQ, OPNE, etc.) are executed by EXCOMP; AND and OR are both executed by EXBOOL. Similarly, EXARTH will handle arithmetic operators.

EXASGN

EXASGN checks both operands for type. A fatal error is generated if either is a file or if only one is a label.

If both are labels, the SYMPOINT pointer for the top operand in the stack (RHS) is moved into SYMPOINT for the second operand (LHS), and the routine exits to POP1.

If they are not labels, the types (SYMBITST, SYMCHRST, SYMFIXPT, SYMFLTPT) are used to compute the location of a pointer to the appropriate type conversion routine. The conversion is performed, so that SVDATA2/SVNUM2 (LHS) now contains the RHS converted to the type and length of the LHS. SVDATA2 is now moved into the location pointed to by the LHS's SYMPOINT. EXASGN then exits to POP1.

The exit through POP1 leaves the LHS in the stack, to permit multiple assignment.

EXCOMP

EXCOMP handles all the compare operators. The types of the two operands are compared, and both operands are converted to the higher type (BIT CHR FIX FLT) and, if strings, to the same length. The appropriate compare instruction (CLC, CLC, C, CD, respectively) is executed, and the resulting condition code and the code halfword from the OPERATOR table are used to compute the address of the result in a table of 1's and 0's. The character 1 or 0, corresponding to true or false, is placed in SVNUM1. SVDATA1 is filled with the first four SYMTAB bytes for a 1-bit bit string, and EXCOMP exits to PUSHNUM1.

EXKNOT

EXKNOT executes the logical NOT operator. It gets the operand and puts it in SVDATA1/SVNUM1, and calls XBIT. It then fills SVNUM2 with 256X'01' and branches to BOOLJOIN (see below).

BOOL

BOOL handles AND, OR, and the post-initialization portion of NOT. It picks up both operands and converts them to bit strings. If one string is shorter, it is padded appropriately. Control then passes to BOOLJOIN.

At BOOLJOIN, the instruction MVC SVNUM1(256),SVNUM2 is placed in SVINSTR. The op code of this instruction is then overlaid with the OPERATOR code from register 8; this code is X'D7'(XC), X'D4'(NC), or X'D6'(OC) for NOT, AND, or OR, respectively. SVINSTR is then executed so the result is in SVNUM1. SVDATA1 is then filled and BOOL exits to PUSHNUM1.

EXCONCAT

EXCONCAT checks the types of the two operands. Unless both are BIT, both are converted to CHR. If the length of the second operand is zero, the result is already in SVNUM1, and control passes directly to CATLEPSY. Otherwise, the appropriate length is computed for an MVC which is then executed to tack the second operand onto the first. If the sum of the operand lengths exceeds 255, the result is truncated to 255. We are now at CATLEPSY. The two operands are popped, the length of the result is stored in SVDATA1, and EXCONCAT exits to PUSHNUM1.

EXSETSTK

EXSETSTK loads register 1 with F'-1' and branches to PUSH.

EXPOPTOP

This involved routine consists of EXPOPTOP EQU POP1

EXVERIFY

This compares the top two words in the stack. If they are equal, control goes to POP2. If they are not, a fatal error is generated.

EXPOINT

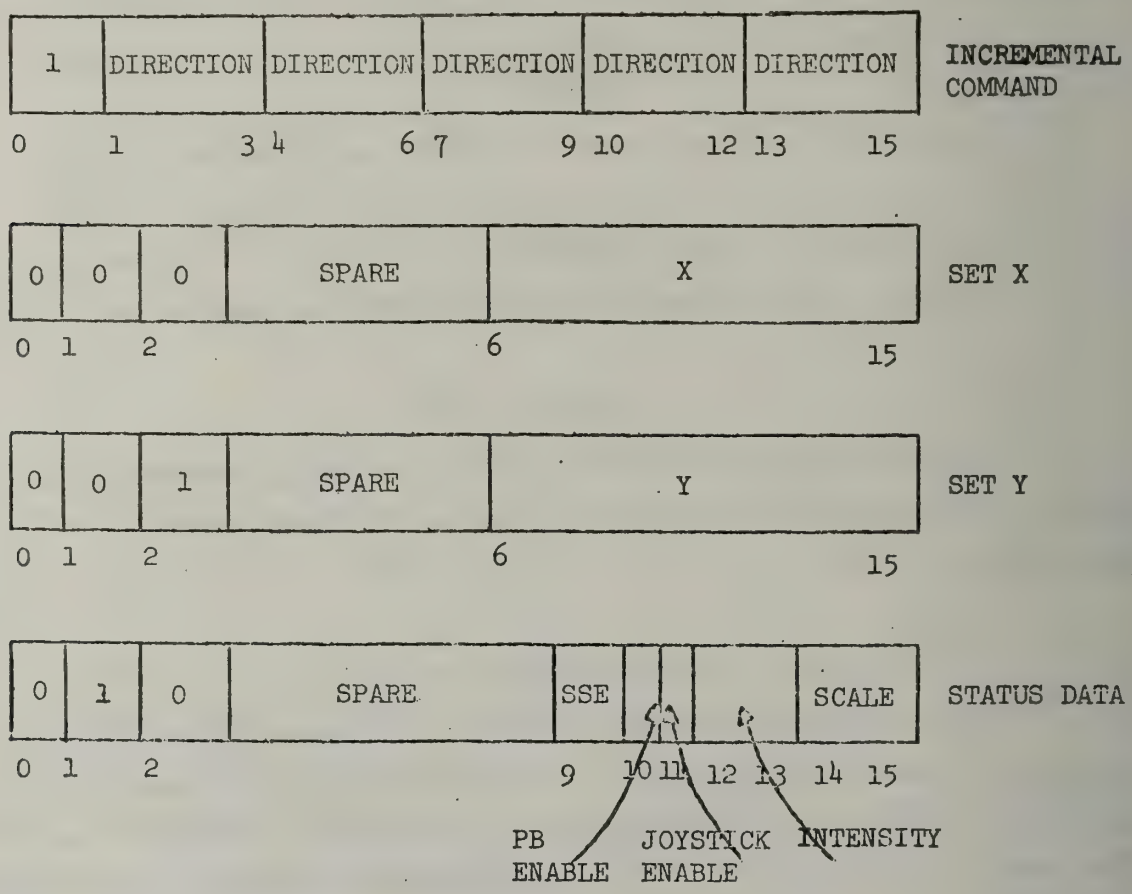
This routine is entered with only one operand (the actual parameter address) in the stack. The routine reads the succeeding polish halfword, converts the halfword to an absolute SYMTAB address (the dummy's) and pushes it. The actual parameter address in the stack is converted to a halfword virtual displacement, which is stored in SYMPOINT in the dummy's SYMTAB entry. SYMFORM is set to SYMDUMMY and SYMDECL turned on in the dummy's SYMTAB entry. Control then passes to POP2.

3.4 Display Processing Unit (R. Hostovsky)

3.4.1 Display Control

The detailed logic design of the display control has been completed. It will operate in the following way:

1. A 16-bit display command is shifted into the Display Control from its respective track of the disk. It may be one of the following words:



The data-rate is 3 Mbit/sec. All operations of the Display Control are sequenced by a modulo-16 counter. The counter is incremented by the disk-track pulses occuring every 300 usec (which are synchronous with the data-rate).

2. To gain speed, the word is decoded immediately on entering the 16-bit shift-register. At time T1, the first bit is examined. If it is a "1", then the rest of the word is interpreted as incremental commands. If it is a "Ø", a further decoding is done on the following two bits.

3. a. The display command is Set X or Set Y type: Signal P2 (or P3) is generated. After the shift register (SR) has been filled (at time TØ), bits SR6-SR15 are transferred into bits Ø-9 of registers X (or Y).

b. The display command is Status Data type: Signal P4 is generated. At time TØ, bits SR14,15 set after proper decoding a 4-bit Scale register. Bits SR9-SR13 set Screen Sensitivity Enable, Push-Button, Joystick Enable and Intensity registers.

c. An Incremental Command. Signal P1 is generated. At times T4, T7, T10, and T13, bits SR13-SR15 are decoded and signals UPX, DOWNX, UPY and DOWNY are generated. Registers X and Y are incremented or decremented with taking the scale into consideration. In scale 1, the UP or DOWN signal, is applied to the least significant bit of the register. In scale 2, the signal is applied to the second least-significant bit changing the register by 2. In scale 3, the signal is applied to the third least-significant bit, etc. The propagation of carry (or borrow) has been speeded by "look-ahead" logic.

3.4.2 Display Processing Unit (DPU)

A flow diagram which describes the internal structure, registers, etc., of the DPU is ready. A detailed design of the DPU is being done now and will be completed by the end of the first quarter of 1970.

3.5 Computer Maintenance and Construction (C. Carter, R. Hostovsky, T. Kerkering, H. Lopeman, R. Miller)

Because of the complexity of the PDP-8 graphics hardware, a special report has been prepared this quarter for use in applications and maintenance activities. It will be made available to prospective users as a hardware introduction to the Graphics system. (DCS Report #371)

The disk controller is completely check-out and the data disk storage is operating satisfactorily for use as a digital storage for the PDP-8 and frame storage for CRT's. A maintenance and design file is available on the data disk controller. (DCS File #818)

The DEC PDP-8 to IBM 2701 interface hardware is check-out and working satisfactorily. This link gives the PDP-8 access to a 360/75 computing system. A report (#372) will be completed next quarter on this interface.

The teletype-inktronic has been added to the PDP-8 configuration giving 2 lines/second print capability. A description of the printer is contained in DCS Report #371.

The "microswitch" keyboard has been checked-out for encoded accuracy but has not been connected to the PDP-8.

The "proto-type" of the display controllers to be used in the multi-console system has been designed. Its construction and check-out will be completed next quarter.

3.5.1 Timesharing Hardware

Sufficient electronic modules have arrived from DEC to provide 24 simultaneous data phone inputs and 16 simultaneous direct-wired inputs to the timesharing hardware. It is hoped that the direct-wired inputs will be distributed in the laboratory during the next few weeks.

A special line connection has been built for a 403 data set for the timesharing hardware. A static test 403-simulator has been used to test the interface. If this proves to be a successful hardware connection, it is proposed as a user inquiry station from touch-tone telephones.

Mathematical Subroutine Library: TRAUBZ

Several changes were made to the TRAUBZ package in converting from CDC 6600 FORTRAN to IBM 360 FORTRAN. Of a minor nature were changes involving the difference in word lengths between the two machines. The 6600 version uses single precision arithmetic, both complex and real, and since the 360 has a 32 bit word as compared to 48 bits for the 6600, the 360 version uses double precision arithmetic throughout. This involved using an IMPLICIT REAL*8(A-H,O-Z) statement in each subroutine and declaring arrays to COMPLEX*16. In addition all constants were changed to double precision. A major change was made to the logic of the BOUNDZ subroutine. The BOUNDZ subroutine finds a lower bound on the modulus of a zero of the polynomial by computing the unique positive zero of the polynomial

$$Z^n + |P_1| Z^n + \ldots + |P_{n-1}| Z - |P_n|$$

where $P_1, \ldots, P_n$ are the coefficients of the deflated polynomial. Originally, BOUNDZ utilized Newton's method for ten iterations, with zero as an initial approximation, and, if there was no convergence, a binary search was instituted using Gershgorin's theorem applied to the companion matrix of the auxiliary polynomial to find an upper bound for the search. Because of the difference in the maximum representable floating point number between the two machines, certain ill-conditioned polynomials caused an overflow on the 360 when summing the coefficients for the Gershgorin process. The modifications to BOUNDZ included using the method of false position for 10 iterations if Newton's method failed, with the last value of X_n calculated in Newton's method used as an upper bound for the false position. If the false position method failed to locate the zero in 10 iterations, then a binary search is used, with the

last 2 values of false position constituting the initial interval of the search. The binary search continues until a zero is found.

Richard Isler
Lloyd D. Fosdick

Mathematical Subroutine Library: Test Matrices

In the process of a compilation of test matrices, two conjectures on eigenvalues and eigenvectors of two of the test matrices have been made. There is strong evidence that each is correct, but we have not yet been successful in proving them to be correct.

Define a matrix A by a square segment of a Pascal triangle with apex in the upper left corner; i.e.,

$$A_{i,1} = A_{1,j} = 1,$$

$$A_{i,j} = A_{i-1,j} + A_{i,j-1} \; ; \quad i,j = 1, 2, \ldots, n$$

It is known that the matrix A is real symmetric, non-singular, and positive definite.

Although we have not proved it, the matrix $1/x^n (A - xI)$ is obtained by performing proper elementary row and column operations on the matrix $A - 1/x\, I$ for any given n. Therefore, the eigenvalues of the matrix A appear in reciprocal pairs. Thus, if e_i is an eigenvalue, then so is $1/e_i$; and if n is odd, then 1 is an eigenvalue.

For n = p-1 where p is an odd prime, define a matrix B by

$$B_{i,j} = \left(\frac{i + j}{p}\right) \; ; \quad i,j = 1, 2, \ldots, n$$

where $\left(\frac{k}{p}\right)$ is the Legendre-Jacobi quadratic reciprocity symbol and is defined as follows:

$$\left(\frac{k}{p}\right) = \begin{cases} 0 & \text{if } p \text{ divides } k, \\ 1 & \text{if } k \text{ is congruent to a square integer modulo } p, \\ -1 & \text{otherwise} \end{cases}$$

It is known that the matrix B is real, symmetric, and non-singular; and that ± 1 and $\pm\sqrt{p}$ are the eigenvalues, and each of $\pm\sqrt{p}$ has multiplicity $(n-2)/2$.

Although we have not proved it, it seems certain that the non-zero components of the eigenvector with eigenvalue 1 or -1 are equal, and that if the i-th component of the eigenvector with eigenvalue 1 is not zero, then the i-th component of the eigenvector with eigenvalue -1 is 0 and conversely. Therefore, we can get the two eigenvectors with eigenvalues ± 1 from the column vector which is the product of B and the column vector whose components are all 1.

For example, in the case of n = 6

$$B = \begin{bmatrix} 1 & -1 & 1 & -1 & -1 & 0 \\ -1 & 1 & -1 & -1 & 0 & 1 \\ 1 & -1 & -1 & 0 & 1 & 1 \\ -1 & -1 & 0 & 1 & 1 & -1 \\ -1 & 0 & 1 & 1 & -1 & 1 \\ 0 & 1 & 1 & -1 & 1 & -1 \end{bmatrix}$$

and

$$B \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \\ 1 \\ -1 \\ 1 \\ 1 \end{bmatrix}$$

Therefore, the eigenvectors with the eigenvalues 1 and -1 are (0, 0, 1, 0, 1, 1) and (1, 1, 0, 1, 0, 0) respectively.

[1] John Caffrey, Another Test Matrix for Determinants and Inverses, CACM, V6, p. 310, YR 1963.

[2] Frank J. Stockmal, On the Inverse of a Test Matrix, CACM, V6, p. 615, YR 1963.

[3] Morris Newman and John Todd, Evaluation of Matrix Inversion Programs, JSIAM, V6, pp. 466-476, YR 1958.

Young Jip Kim

Lloyd D. Fosdick

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C. W. Gear
Principle Investigator

Organization

Department of Computer Science
University of Illinois
Urbana, Illinois 61801

Signature	Date
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4. ILLINOIS PATTERN RECOGNITION COMPUTER: ILLIAC III

(Supported in part by Contract AT(11-1)-1018 with the U. S. Atomic Energy Commission)

The Illiac III Computer System can be described in terms of 14 constituent subsystems of processors, units and peripheral device groups as follows (see Figure 1):

i) Central System (6 subsystems)

ii) I/O System (3 subsystems)

iii) Peripheral System (4 subsystems)

iv) Power Distribution System (global to all subsystems).

Only one, the Fast Core Storage Modules, is of commercial design. The other constituent subsystems have been designed almost entirely as part of the graduate research program of the Department of Computer Science.

This massive design/development program was not undertaken lightly. Rather, central to the contract program has been the study of the computer architecture appropriate for high speed image processing. These peripheral devices, units and processors must be able to talk to one another -- and with minimum data format conversion: the Scanners feed the Pattern Articulation Unit, whose output in turn is interpreted by a Taxicrinic Unit. This global integration of the design has been costly but integral to the integrity of the system design presented here.

4.1 HARDWARE DEVELOPMENTS

4.1.1 Taxicrinic Processors

Editing on Volumes II and III of the TP Manual has been continued. All drawings and most text are now complete.

The format for the final version of the TP Control Logic drawings is currently being considered and several preliminary formats are currently being tried out. Most of the control logic drawings are still in uncorrected pencil draft, however.

One sequence for the co re machine has been assigned to a card for layout to check procedures.

B. J. Nordmann

4.1.2 Fast Core Storage Units

Both core memories are now operational.

S. Paul Krabbe

4.1.3 Arithmetic Units

During the last quarter, editing and final typing of Volume I of the AU Manual were completed. The document is available from the Department of Computer Science Mailing Center as Report No. 366.

D. E. Atkins

4.1.4 Pattern Articulation Unit

Work will begin on the control design again early next quarter.

During the last quarter, the display system wiring was completed. Final checkout of the display system and initial checkout of the Transfer Memory are only waiting for power.

R. T. Borovec

4.1.5 Interrupt Unit

The IU logical design and control flow charts were completely modified to incorporate the console processor in the system. Logic drawings were drawn and some thought was given to card layout. Documentation for IU is being written up and should be available in the next quarter.

Lakshmi N. Goyal

4.1.6 Exchange Net

Checkout of the Exchange Net will begin when DC power becomes available.

S. Paul Krabbe

4.1.7 I/O Processors

IOP Command Structure

Documentation of the Interrupt Commands and the Device Dependent Commands is complete. The description of the IOP program registers and the channel registers is in progress.

The introduction to the Interrupt Command Section describes the basic procedure for executing an I/O process. The rest of this section enumerates the operations performed by the IOP for each of the interrupt commands, and it defines all interrupt command formats in detail.

The introduction to the Device Dependent Command Section puts the concepts of the Device Dependent Commands (DDC's) and their Data Descriptors into perspective and describes the steps the IOP takes while executing a DDC. The body of this section describes the formats of the DDC's, the formats of the various I/O Descriptors, and the basic operations performed by the seven DDC's.

The section on the registers discusses the relations between the program and the channel registers. In addition, it describes the information stored in the various registers and the operations performed on the registers.

Linda M. Katoh

4.1.8 Channel Interface Units

Due to higher priority assignments no material accomplishments have been made on this task.

Joe Wenta

4.1.9 Device Controller

The completion of the control flowcharts for the communications link between the Device Controller and any Illiac III I/O device is still pending. The basic S-M-V Controller has just become operational; hence, using the experience to be gained from its operation, the Device Controller specifications can now be completed.

Val G. Tareski

4.1.10 S-M-V Controller

Three basic portions of the Controller concerned respectively with parameter information read in, beam motion and the scanner/monitor communication were checked out this past quarter. A manual control box was used to load parameter information, consisting of 20 bytes of 8 bits each, into the 46 mm scanner; the beam motion control was then employed to exercise the processing hardware. Film was scanned and displayed at a monitor via the scanner/monitor communication control. Four bits of gray scale information doubly decoded (analog - digital - analog) in the scanner was presented at the monitor at a 1 MHz rate. The realization of these three portions of the Controller used 217 control points and associated gates and were packaged in a total of 50 integrated circuit cards.

The buffer and bypass communication controls are now being wired and the actual reading of digitized picture information either into or out of core should be accomplished early within the next quarter.

Ronald Martin

4.1.11 Scan/Display Devices

A breakdown of the current status of listed devices for Illiac III emphasizing what has been added since September, 1969, is given below.

The devices are listed by type. Both scanners of each type are briefly covered. "F" units are inboard scanners; "H" units are outboard.

1. 70 mm Scanners

Unit F

Unit F has the transport plate, motors, and pneumatic system pulled out and mounted in a test frame for easy access. It is being used to test transport motor control operation to establish motor drive and film tensioner characteristics for the 70 mm and 46 mm transports. The C.R.T. mount, coil mounts, and shield are installed.

Unit H

Unit H was the first scanner put in operation before the "simplified scanner" scheme was developed. Except for the film motion motor control, it is operational and awaiting electronic modifications for changeover to the simplified version. The experimental light pipes are installed in this unit and will be re-tested when the latest version analog PMT system is installed. The "old" collection optics lenses may be re-installed if the light pipes do not prove superior.

2. 46 mm Scanners

Unit F

This is now the operational unit linked to core and the monitor. It is fully operational in terms of electronics, and is under complete remote manual control at the monitor (in terms of film transport). Presently the large slew motors and film tension servo potentiometers are not operable. However, the small stepping motor has proven capable of driving some 45 feet of film images forward and backward in the unit. We thus now have selectable film images at the monitor.

Unit H

Unit H is not operational but has the following components ready for use: Transport mechanism, motors, pneumatics, collection optics, C.R.T. mount, C.R.T. coil mounts and shield.

3. 35 mm Scanners

Unit F

Unit F is "bare" in terms of optical/mechanical components except that the C.R.T. mount, coil mounts, and shield are in place; and a microfiche transport is ready to be installed but will await testing of the similar transport placed in Unit H. The 35 mm camera intended for this unit was not installed because it must be checked and repaired due to fire damage.

Unit H

This will be the first unit built up. At present it has the "good" 35 mm camera, a 16 mm camera, and a basic microfiche transport mounted in place. Also the C.R.T. mounts, coil mounts, and shield are

installed. The collection optics for the 35 mm unit are essentially complete and ready, but the transfer mirrors and lens for the microfiche unit are still being designed. A temporary set of mirrors is ready for the 16 mm camera, so that movies can be generated as soon as C.R.T. and control are ready.

4. Microscope Scanners

Unit F

This unit awaits control. The stage, optics, and collection optics are installed. The motors are here but not yet installed. The C.R.T. mount, coil mounts, and shield are in place. The moiré fringe gratings are on order. While the optical mounts are in place, some additional objectives and a condenser must be provided.

Unit H

This unit is not quite complete in that the stage carries the original motors which had the fields damaged when rebuilt following the fire. The fields will be "repaired" and the motors re-installed. The Z axis stepping motors on both units are in place. Moiré fringe gratings are on order, and additional optics as above will be provided. C.R.T. mount, coil mounts, and shield are in place.

5. Monitors

Two monitors are being built-up. One is now operational and runs with the 46 mm scanner, Unit F. The other is being wired. The mechanical assembly of two register display and control panels for these monitors is complete. They await lamps and switches before final assembly and wiring.

6. High resolution television

One 1536 line T.V. system has been mounted in a console and linked to a complete microscope (independent of scanners). Both fast and slow scans are available at the unit. Picture quality is extremely good and will get better. Maximum screen magnification available at present is 1136 x (40 x objective) and can be boosted by getting higher objectives. Resolution on the screen is nearly comparable to visual limits (but not quite). This system is completely operational.

R. C. Amendola

4.1.12 Intermachine Link

The hardware for the link to the PDP8 was completed and checked out during the last quarter. A slight timing problem still exists in as far as accessing core is concerned. This problem will be solved in the coming quarter.

4.1.13 Low Speed Terminal Network

No progress was made this quarter because of the attention given to matters of higher priority.

R. P. Harms

4.1.14 Power Distribution

The wiring of both the processing and control hardware is about 95% complete.

Power turn-on of the first two stages is complete and power is now being applied to the various sections of the mainframe.

Ronald Martin

4.2 SOFTWARE DEVELOPMENTS

4.2.1 Supervisor-Processor Interface Definition

The supervisor section of the TP Manual has undergone extensive editing this quarter in preparation for the flowchart specification of supervisory instructions of the Taxicrinic Processors. However, no flow charts for these instructions have been produced yet.

B. J. Nordmann

4.2.2 S-M-V Test Programs

The system routines were completely debugged during the last quarter. Since the primary effort is now directed towards getting into the 360, only the scanner test program will be written. More exotic routines may be written by interested users.

Richard T. Borovec

4.2.3 Taxicrinic Processor Simulation

Work is being continued on the control sequences of the TP. Two control sequences are completely debugged, and at least ten others are coded and are in the process of being debugged.

Although this phase of the simulation is a time-consuming task, it has proven to be quite valuable in debugging the design logic and the logic of the control sequences themselves.

The simulation of control sequences is being done in such a way that it will be valuable for use in checking out the future hardware wiring.

Mary Ann Hagen

4.3 DOCUMENTATION

4.3.1 Engineering Manual

No additions were made to the engineering manual this quarter.

Ronald Martin

4.3.2 Circuit Books

Five new variants of circuits have been documented and are ready to be released for distribution to Circuit Books.

One new circuit is in process of documentation at this time.

4.3.3 Logic Documentation

No new entries into Logic Books have been made during the past quarter.

Total of 65 new intermediate logic drawings and 14 changes of existing drawings have been processed by 1018 Drafting Section.

During this quarter, total of 238 drawings (including drawings related to Opto/Mechanical design of Illiac III scanners) have been processed by 1018 drafting section as follows:

Large drawings	81
Medium drawings	29
Small drawings	67
Report drawings	6
Layouts	2
Drawing changes	26
Miscellaneous	27
Total	238

4.3.4 Wiring Tables

The following wiring tables were compiled by PØØL during the last two quarters (last quarter was not reported).

SUBSECTION	SECTION #	NO. OF WIRES
DC Power	91	4167
AC Power	95	705
DC Power	91	286
DC Power	95	2862

S. Paul Krabbe

4.3.5 Opto/Mechanical Design Documentation

Due to shifts in personnel and their duties, opto/mechanical design has been at a near standstill for this period. Progress is hoped for in the next.

For the period 1 August 1969 to 31 December 1969, four (4) new detail and layout drawings were made.

Three (3) work orders went to DCS machine shop; one (1) went to Physics shops; and one (1) went to the Electrical Engineering Department, electro-chemical lab.

R. C. Amendola

4.4 Pattern Recognition Theory

4.4.1 Graph Transformation Grammars

An example of parsing a simple house type figure was added to the paper "Graph Transformations for Composite Formation" and the paper was issued as Report No. 368 during the quarter. In the example, the concept of an "information lossless" graph transformation is defined in order to form higher level composite elements during a parse. The ideas of the paper are applied to show how information lossless transformations may be determined from the properties of the binary relations of the graph. In this way, the initial name-independent part of a picture parsing procedure is carried out.

Another relation-orientated parsing method was studied and one phase of its transformations were shown to be justified by the information lossless criterion.

Currently, some other early linguistic approaches to picture processing are being reviewed to determine to what extent they fit into the formulation of parsing by means of information lossless graph transformations.

John C. Schwebel

4.4.2 Analysis of Block-like Scenes

The study of the name-independent recognition of objects in scenes based on Guzman's work with block-like objects demonstrated that this application area could be treated adequately by a more general relational formalism.

An attempt is being made to apply this formalism to more complex scenes, such as coloring book cartoons, by using additional types of local information to establish graphic links.

John C. Schwebel

Reports and File Numbers Issued

Report Number	
Report No. 358	Harms, Richard Paul, "Modeling of Domain Growth Activity in Polycrystalline Ferrites", Masters Thesis November, 1969
Report No. 366	Atkins, Daniel E., "Illiac III Computer System Manual: Arithmetic Units Volume I", December 11, 1969
Report No. 368	Schwebel, John C., "Graph Transformations for Composite Formation", December 12, 1969

File Number	
File No. 810	Franco, Sergio, "A High Speed Analog Divider for the Illiac III Scan System", October 3, 1969

Senior Staff

Professor Bruce H. McCormick - Principal Investigator
Professor K. C. Smith - Consultant

Professional Staff

Robert C. Amendola
Richard T. Borovec
Mrs. Linda M. Katoh
Ronald G. Martin

Electronic Engineering Assistants

S. Paul Krabbe
Joseph V. Wenta

Electronic Technician II

John L. Fileccia
Robert G. Thomson

Electronic Technician I

George T. Lewis
Bennie D. Williamson

Engineers

*Daniel E. Atkins
*Jayaramamurthy
*Lakshmi N. Goyal
*Richard P. Harms
*Bernard J. Nordmann
*Christian Rey
*Val G. Tareski

Programmers

*John C. Schwebel

Drafting

Stanislavs Zundo

Secretarial

Mrs. Mariam Coleman

---

*Research Assistants

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5. ILLIAC IV

(This work was supported in part by the Department of Computer Science, University of Illinois, Urbana, Illinois, and in part by the Advanced Research Projects Agency as administered by the Rome Air Development Center, under Contract No. USAF 30(602)-4144.)

REPORT SUMMARY

The Advisory Committee Meeting was held at Burroughs (Paoli, Pennsylvania), October 30-31, 1969. The purpose of the meeting was to review the status of the Hardware being constructed at Burroughs, and to review the work being done on Software at the University of Illinois. Burroughs demonstrated the PE and other subsystems. It was tentatively agreed that a future meeting be planned to give a close scrutiny to programming languages being developed (e.g., TRANQUIL, GLYPNIR, FORTRAN).

The semi-conductor memories to be produced by Fairchild for Burroughs are still behind the production schedule, due to yield problems with the memory chips. The first memory delivery to Burroughs is expected March 16, 1970 (a slippage of two months); the last (70th) memory is scheduled for delivery on June 5, 1970 (a slippage of one month).

The prototype processing element has been built--Burroughs has begun production of the PE--and most instructions have been "debugged." A minor "slow down" is expected in the twenty megahertz clock as a result of testing being performed on the prototype PE.

Software and hardware for the PEX Control Computer (PDP-9) have been completed; the computer will be shipped to Burroughs in January. The first of the University's production diagnostics for printed circuit cards and the processing element have been delivered to Burroughs.

Burroughs has submitted fixed price proposals for ILLIAC IV documentation, power supplies, and PE's. These proposals are currently being evaluated.

In December, a Project Business Office (PBO) was established for the ILLIAC IV Project. This office will deal with internal administration--budgets, building requirements--and will interface with the University Administration.

Bids for the construction of the Center for Advanced Computation building were received and approved by the University of Illinois Board of Trustees; a contractor has been selected, and construction of the building has started.

5.1 Logic Simulation and Diagnostics

5.1.1 Logic Simulation

5.1.1.1 PE Simulator

The net lists (wire lists), generated during the previous quarter for the 37 Processing Element (PE) card types, have been maintained and updated during this period. In addition, net lists for the 5 Memory Logic Unit (MLU) card types were compiled from Burroughs logic diagrams; errors in translation and in card punching of the net lists were removed completely. All of the MLU card net lists have been released for simulation and test generation.

5.1.1.2 CU Simulator System

The Control Unit (CU) Card Logic Simulator System of programs (except the simulator Body Generator and Merge programs) have been modified, wherever necessary, to satisfy the requirements of the CU-Section System.

The modified Update program will delete or insert records into the backplane wire list and will rearrange the records into the form required by the WEDTR1 program.

The new WEDTR1 program will detect missing wires and produce an error list on disk which can then be used as input to the Update program. It is not possible to exactly update the wire list in this program; however, the program does provide a way to add many of the interface signals. Otherwise, this program is similar to the earlier WEDTR1 program, except that the disk spaces are larger--to accommodate the larger files.

The WEDTR2 program now accepts a file which is the result of partitioning a CU card into three parts: Input, Output, and Combinational parts. Partitioning is effected to increase the efficiency of

simulation for such situations as the occurrence of looped storage elements. During the pin sorting block, each pin is examined to see whether it belongs to Input, Output, Combinational or to any combination of the three partitions of the card. Due to the partitioning, some logic elements will be duplicated in the cards--this information is added to the file while processing it. WEDTR2 produces an arc list which takes into account the partitioning, and sorts the records by the package location and pin number.

The only modification in the Leveler, Reduce and Housekeep programs is the enlarging of the disk spaces to handle larger files.

5.1.2 Card Test Generation

5.1.2.1 Card Test Generator System

The Card Test Generator System was used during this period to obtain test patterns for some PE and CU cards.

Due to the higher complexity of the CU cards, slight modifications of the basic system--such as the ability to use manually generated input patterns with the aid of TESLA, merged with inputs generated by the Pattern Generator program as inputs to the simulator--have been implemented.

The necessity of generating additional information to be used by the Test Translation program for fault location purpose required the addition of a new program to the system. An initial version of this program is operational and a new version of the program with increased capability is under development.

5.1.2.2 Card Test Translation

Work in this field was concentrated in three principal areas: production of test dictionaries (including input and output patterns); automatic translation of test patterns into PEXTAP programs suitable for use with the CU Card Tester Adapter for the PEX; and automatic

translation of test patterns into programs which can be run on the Texas Instruments 561 Logic Tester which will be used to test PE cards.

Test patterns produced by the Test Generator System are converted into test dictionaries which are used for manual switch tester debugging of cards and to provide detailed information when failures are detected by any of the automatic procedures.

For each output pin of a board, failure modes, (and any indistinguishable equivalent failures) which can cause an anomalous output, are listed. In addition, cross references between failure modes and test patterns are supplied to simplify the task of fault location. Although the test dictionary production program previously existed in a primitive form, extensive revisions have been made to provide additional information to the user and to format the information in the most useful manner.

A working version of the PEXTAP translation program has been completed, and PEXTAP code generated by it has been sent to Burroughs for evaluation. Further improvements will be made during the next quarter.

Programs have been written which automatically generate valid programs for the TI-561A Automatic Printed Circuit Card Tester. These programs will be used to generate programs for testing various PE boards. They are generated from the wire list of each board and the failure test patterns applied to each input pin with the associated expected good output. The programs have been written within the constraints imposed by Burroughs on the assignment of input pins to the Texas Instruments 561 Logic Tester. The boards for which satisfactory test generation can be performed are static (i.e., no latches) logic boards with 27 input pins or less. A modified program will be written to generate the test program for those boards with more than 27 input pins. Special routines for setting and resetting latches, which, thus far, have not been written, are necessary for testing this type of board. In addition, possible problems exist if non-standard voltage level assignments are required on special boards.

5.1.2.3 Generation and Evaluation of Card Tests

All of the PE card tests generated by the Card Test Generator System have been released to Burroughs for production testing of PE cards. These tests, however, will be revised in accordance with card design modifications and improvements in the Test Generator System.

MLU Card Tests are being generated for production testing.

Significant improvements in the Test Generator System give higher resolution in locating failed components with test dictionaries. An example of the new test dictionary has been sent to Burroughs.

All of the revised PE card tests including the MLU card tests are ready to be generated whenever design modification information is available from Burroughs.

A correlation of failure modes in DIL's from a circuit analysis by Burroughs to a logical analysis by the Diagnostics group was completed for ten of the metal patterns. This correlates actual circuit failure modes with the failure modes assumed in the Card Test Generator. One class of circuit failures was found which is not presently covered in the Card Test Generator. It will be covered when analysis of all DIL types is completed.

5.1.3 PE Diagnostics

5.1.3.1 Path Test

The Detection Phase Path Tests for the Prototype PE have been released to Burroughs after some errors in expected responses were removed. A few errors and failures in the prototype PE and the PE exerciser were found; some of them were located with the Detection Phase Path Test. The Detection Phase Path Test is also valid for production PE testing.

Since a masking function is required, the Location Phase Path Test should be executed with the PEX under computer control. (This masking function cannot be provided by the PEX--it must be performed by the PDP-9.)

The test dictionary of the Location Phase Path Tests will be useful to locate failures with the Detection Phase Path Tests until the PE exerciser is hooked up to the PDP-9 and the control program system in the PDP-9 supervises the Location Phase Path Test by its masking function.

5.1.3.2 Combinational Test

Re-evaluation of the combinational tests was started again in this period. Several functional tests will be released, one-by-one, after verification with the PE simulator.

5.1.3.3 Control Logic Tests

The main task in this quarter was to find a good algorithm to check sneak paths in the graphs corresponding to Boolean equations of PE control logic.

An algorithm with parallel checking capacity is used for the test generation (EQUATN/TESTGEN).

In order to take advantage of the parallel checking, two programs (EQUATN/RNDNAM2 and EQUATN/REVPTH1) were written prior to EQUATN/TESTGEN. These two programs change the formats of PGM output files, and some others, in order to fit the required formats of input files of EQUATN/TESTGEN.

The program EQUATN/TESTGEN has been written and is being debugged. This program will give the test patterns for the PE control logic. The number of tests is approximately 450. This set of tests is good, not only for detecting, but also for locating the failures in the PE control logic.

5.1.3.4 Functional Tests

In this quarter, functional tests were run on 23 test routines and the results were sent to Burroughs. In several cases, the PEXTAP source code was changed to eliminate discrepancies between actual and expected responses in the simulator portion of the tests.

The ACT program required modification to make it more general and to improve its execution efficiency. It now translates from assembled PEXTAP code to simulator input code and rearranges the input for parallel simulation at an average of 270 cards per minute.

5.1.4 PEX Computer and Supervisor System

Both the hardware and software systems necessary for interfacing the PDP-9 computer to the PEX were completed during this quarter.

The necessary components for the PEX interface arrived at the beginning of the quarter and interface construction was accomplished with a minimum of difficulty. The interface was completed at the same time as the PEX supervisor software. To permit the latter to be checked out, additional logic was temporarily added to the interface to simulate the reactions of the actual PEX. The interface and the software were then debugged as completely as possible without actually being connected to the PEX.

The minor modifications which must be made to the PEX are currently being done by Burroughs. It is anticipated that the PDP-9 will be shipped to Paoli at the beginning of the next quarter.

The PDP-9 has proven useful in other ways. Utility routines have been written which produce paper tapes for both the PEX and the TI-561 from B5500-generated magnetic tapes. This eliminates the need for extra-project computer services which were previously necessary for such conversions.

5.2 Design Automation

Within the past quarter, the layout of CU-boards was completed. Forty-five computerized layouts were completed at the University for Burroughs Corporation. With the completion of the CU-artwork, all of the detailed PC layout for ILLIAC IV is now complete.

5.3 Operating Systems

5.3.1 Operating System I

The operating system is in the last stages of coding and debugging that can be performed on the B5500. The design is completely frozen. After final debugging on the B6500, the effort will turn to 1) remedying deficiencies in the design and 2) accommodating the input/output provisions incorporated in TRANQUIL, GLYPNIR and ASK.

5.3.2 Operating System II

5.3.2.1 Introduction to Operating System II

The primary motivation for the SYSTEM II approach is to achieve maximum use of the ILLIAC IV array. Fundamental is that the control portion of the complete algorithm be explicitly placed on the B6500 which, as the hardware is designed, is the controller for even such intimate actions as transmissions between ILLIAC disk and PE memory. The foundations of the approach are the ILLIAC KERNEL statement and ILLIAC resource allocation declarations which will be added to a standard B6500 compiler (e.g., FORTRAN), and extensions to the B6500 Operating System (MCP) which are designed to include ILLIAC IV as a resource of the composite system.

The applications programmer merely embeds (non-nested) ILLIAC computations in his "control program" which is thereby tailored to control the set of ILLIAC computations which are embedded in it. Thus, such actions as program segment overlay and core-disk data transmissions are specified in a natural way by the applications programmer without his thinking about this facet of his program's interaction with the system. Multiprogramming between such programs, and multitasking within them is fully supported by the Burroughs MCP. Finally, an incremental

approach to ILLIAC IV is provided by the language which is central to the SYSTEM II approach since the B6500 compiler's language is a proper subset of that language.

Implementation of the MCP extensions has begun by writing them in SIMULA--a simulation language which parallels the facilities of ESPOL (the language in which the MCP is written) very closely.

5.3.2.2 The KERNEL Statement

The canonical KERNEL statement is a quadruple whose ordered four parts are:

1) PE memory declarations local to the KERNEL block;

2) Input transmissions from ILLIAC disk to PE memory all of which must be recognized as complete by the B6500 before the next step can proceed;

3) The ILLIAC computational algorithm;

4) Output transmissions from PE memory to ILLIAC disk, which must be complete before KERNEL completion notification is given to the B6500 control program.

All of the information necessary to execute a given KERNEL must be available in the B6500 at run time when control reaches the KERNEL; thus, input and output record indices and ILLIAC memory size requirements can depend on variables whose values are available in the B6500 at the time KERNEL execution is called for. However, no parameters for a given instance of a KERNEL can depend on values determined by the execution of that instance of that KERNEL.

Any combination of the constituents of a KERNEL may be elided; not all of the allowed combinations are logically desirable, however.

Three forms of KERNEL executions are possible. They are

1) ILLIAC <KERNEL quadruple>; the B6500 waits until KERNEL completion before proceeding.

2) ILLIAC PROCESS <KERNEL quadruple>; the B6500 proceeds immediately to the next statement;

simultaneous processing occurs on the ILLIAC array and the B6500.

3) ILLIAC ON <event designator> <KERNEL quadruple>; KERNEL completion causes the specified EVENT; simultaneous processing occurs on the ILLIAC array and the B6500.

5.4 Translator Writing System

During this quarter, ISL/DISK was added to the system, completing the system as outlined previously. Thus, a user may write the syntax of his language in TWINKLE, write the semantics in ISL, and generate a compiler--simply by giving everything to TWINKLE/DISK--the other necessary programs will be run in order automatically. Also, it is possible to run each step independently, if that should be desirable.

The documents describing ISL, the Translator Writing System, and TWINKLE have been produced.

An effort was begun to overhaul the parser files to make them as small and as efficient as possible. A patch to the ALGOL compiler to allow conditional voiding of cards was added. Also, some new action calls (parameterized, setting and testing a bit, incrementing or decrementing and testing a counter) will be added which will allow certain features to be done more quickly than would otherwise be possible.

A persistent problem with one of the Floyd production groups has been solved and the necessary changes to implement the solution will be made along with the above changes during the next quarter.

5.5 Compilers and Translators

5.5.1 TRANQUIL

The TRANQUIL group participated in a benchmark effort which clearly showed that the current compiler would produce code which would not execute sufficiently efficient to attract users. In the interest

of improving these figures, the TRANQUIL group has engaged in a substantial project of evaluation.

At the same time, efforts to debug the current compiler were continued, primarily in those areas not directly affected by the evaluation. The areas of set definition and operations, procedure calls, and sequential loop control have now been successfully simulated. The TRANQUIL group has also been preparing for another reduction in personnel and general reallocation of resources.

A document entitled "A TRANQUIL Programming Primer" [1] has been produced. It will be available for distribution early in 1970. It includes a good description of the TRANQUIL language and its use, comparisons with FORTRAN and ALGOL, and exercises and answers against which the reader may test his skill.

5.5.2 GLYPNIR

A review of the status of GLYPNIR was made during the last quarter of 1969. The leadership of the project was transferred from Duncan Lawrie to James L. Parker. It was determined that GLYPNIR should be given a larger exposure to users and that classes in GLYPNIR programming would be held.

The mathematical subroutine library was almost completed. A FOR statement which utilized the machine fast loop and index instruction was added. Code has been inserted to accept the "VECTOR" declaration. Writing of a user's manual to complement the education program was begun.

Further projects for expanding the language are:

Extended indexing
Extended routing
CU index variable
Define macro facility
32-bit arithmetic

5.6 Assembler

Work was begun on the macro assembler in September. By mid-November, a first version was running on the B5500. At this time, work on the assembler was suspended for the remainder of the quarter in order to investigate the feasibility of the next version of the Operating System (System II).

5.7 B5500 Operation

	No. of Jobs	Process Hours
October	10,151	287.94
November	9,603	252.18
December	9,697	93.38

The present status of the MCP is Mark X, LEVEL 00.19. Machine use has been moderate to heavy, with an average of approximately 330 jobs being run per day (throughput has been very good).

Design Automation finished their work and gave up their use of the machine on November 24, 1969.

Batch Processing is now being offered as a service to all users. A Cold Start procedure has been initiated in which user's files are no longer dumped.

5.8 Numerical Analysis

5.8.1 Monte Carlo Transport

Work on Radiation Transport phenomena, using a Monte Carlo method, is being continued. The geometry being considered is two-dimensional (cylindrical symmetry) with domains consisting of 32 x 64 cells. Density is a function of space, while the absorption and scattering coefficients are functions of temperature. The process is nonlinear in the sense that the number of photons to be emitted in each cell is dependent upon the temperature, which is in turn re-evaluated after each time step according to the energy transferred to each cell.

The process has been coded into a number of subroutines (about twenty), some of which will be combined after debugging. The programs have been written in GLYPNIR and have been partially debugged using the simulator.

5.8.2 Eigenvalues

5.8.2.1 Matrix Storage Methods

5.8.2.1.1 Matrix Storage for Jacobi's Method

The modified Jacobi method for eigenvalues of symmetric matrices has been revised.

(1) A new "triangular-skew" storage scheme has been developed [2] which makes possible a more efficient moving of elements in core. The mapping of the elements a_{ij} into PE-memory is done as follows:

$$\text{for } 0 \leq i \leq \frac{n}{2} - 1, \quad j \geq i$$

$$a_{ij} \rightarrow \text{loc } i,\ \text{PE}\left[\sqrt{n}\ (j(\text{mod } \sqrt{n})) + \left\lfloor \frac{j}{\sqrt{n}} \right\rfloor + i(\sqrt{n} + 1)\right] \quad (\text{mod } n)$$

and for $\frac{n}{2} \leq i \leq n - 1$

$$a_{ij} \rightarrow \text{loc } j - \frac{n}{2} + 1,\ PE\left[\sqrt{n}\ (i(\text{mod } \sqrt{n}) + 1) + \left\lfloor \frac{i - (n/2)}{\sqrt{n}} \right\rfloor + (j - \frac{n}{2})\ (\sqrt{n} + 1) + 1\right] (\text{mod } n)$$

n is the size of the matrix such that $\sqrt{n}$ is an even integer and $\lfloor x \rfloor$ is the greatest integer $\leq x$. Any n not satisfying this relationship is adjusted in a manner fully described in [2].

(2) The classical and modified Jacobi methods are described in "Eigen-Value Problems" [3]. In that document a shuffle of the first row and first column was suggested in order to subject all off-diagonal elements to the elimination process.

A major time-saving factor has been found by not subjecting the matrix to the above mentioned type of orthogonal transformation but rather to the orthogonal transformation

$$H\ A\ H^t \qquad \text{with } H = \begin{bmatrix} 0 & I_1 \\ I_2 & 0 \end{bmatrix},\ H\ H^t = I$$

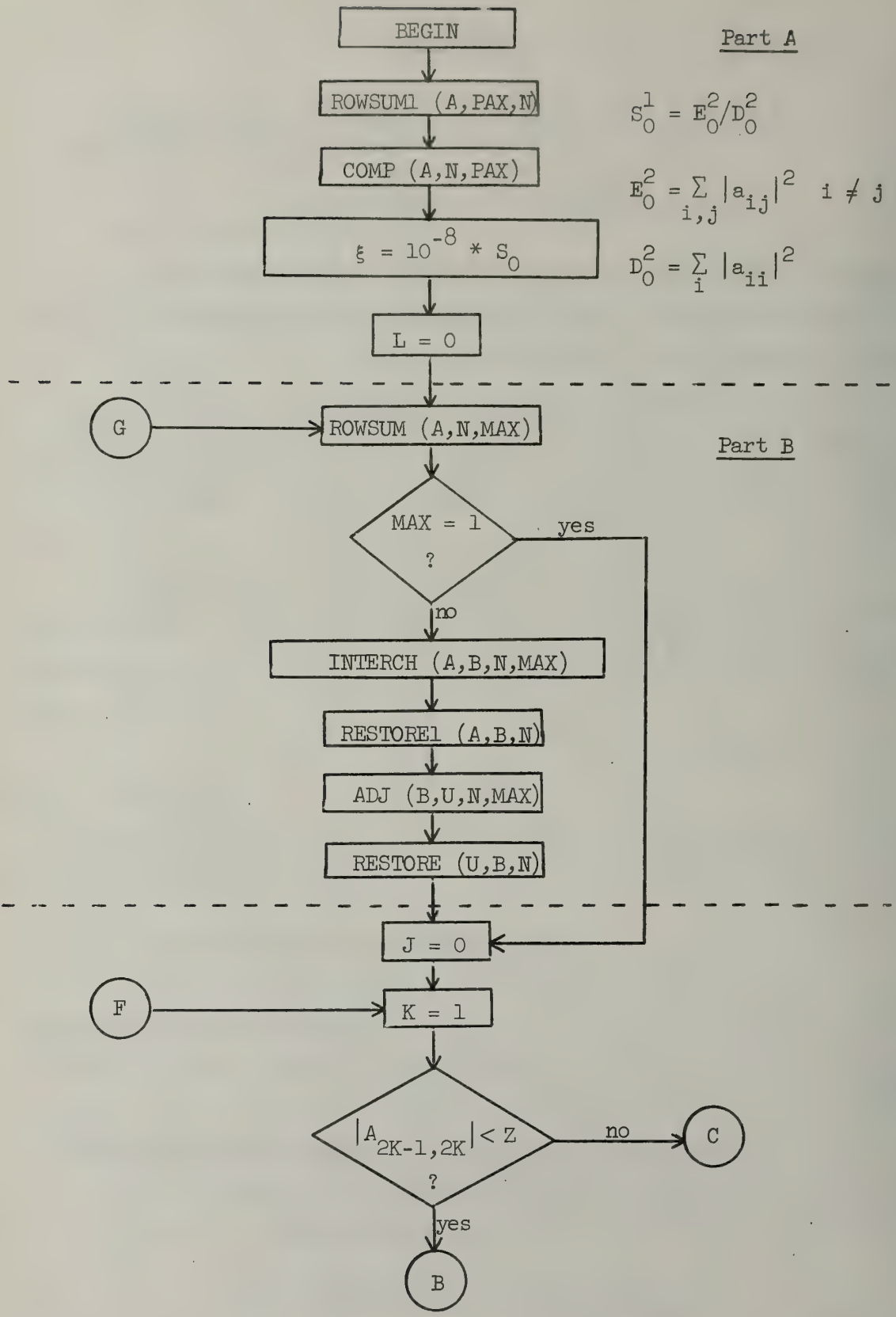
where I_1 is an $(n - m) \times (n - m)$ and I_2 is an $(m \times m)$ identity matrix. The factor m is determined by

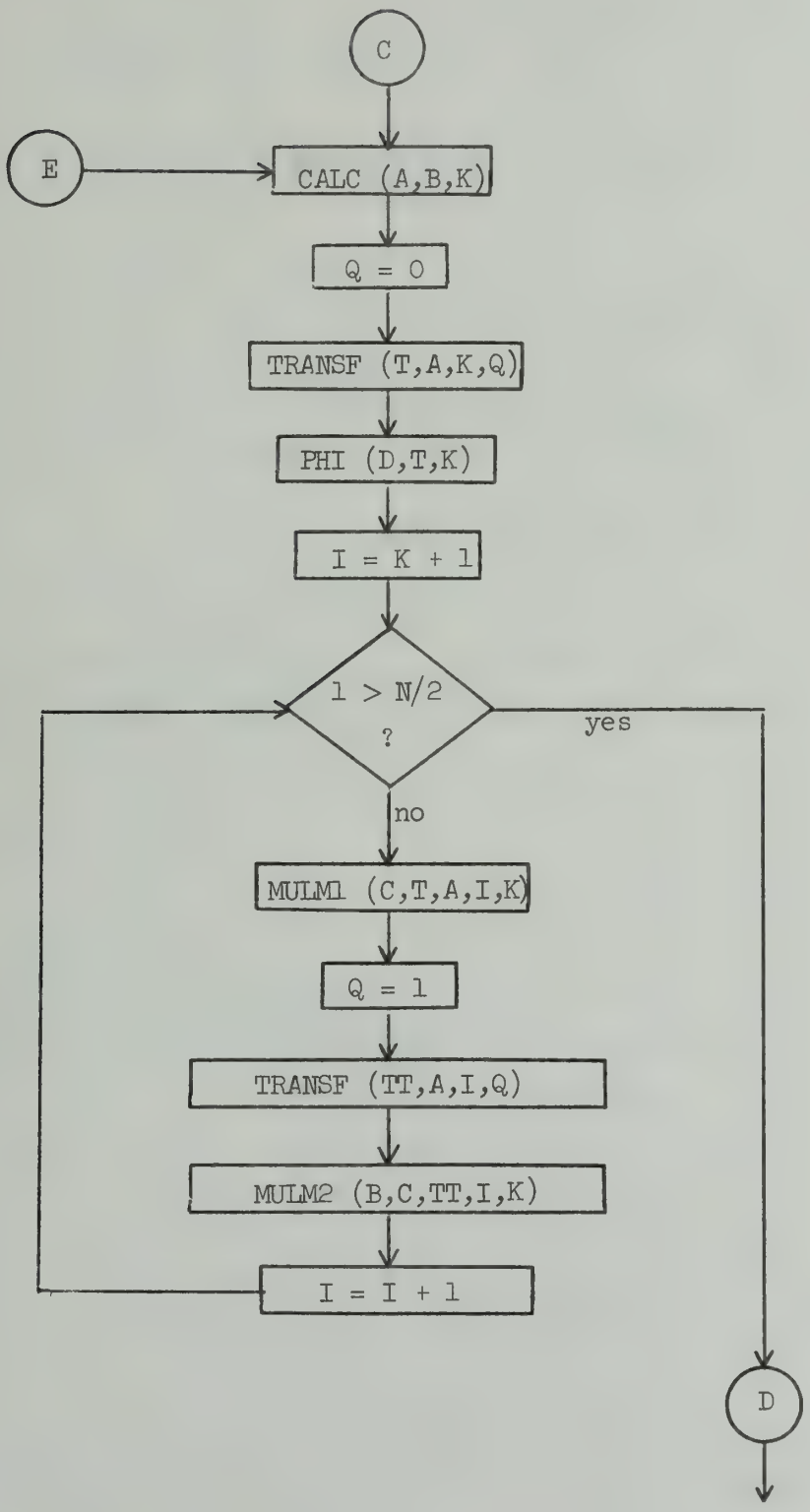
$$\max \sum_j |a_{ij}|\ (i \neq j)$$

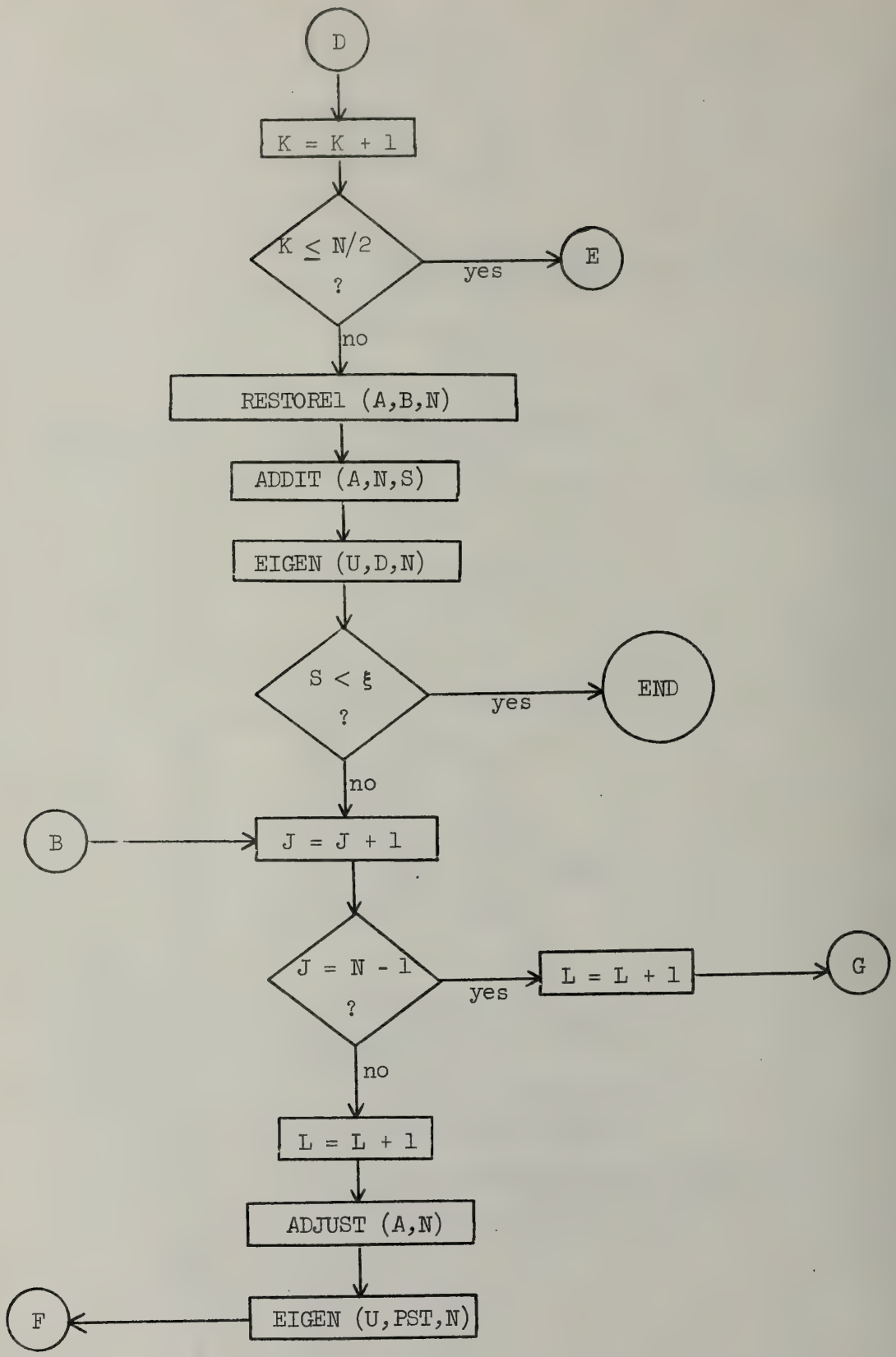
i.e., m is the row index, i, which contains the maximal value of the sum of the absolute values of the elements in this row. (See flow chart, part B.)

(3) It may be noted that Jacobi's method can be applied to the set of all symmetric matrices by subjecting the matrix A to the test of diagonal dominance according to the criterion

$$|a_{ii}| \geq \sum_{i,j} |a_{ij}| \qquad (i \neq j).$$


BEGIN
ROWSUM1 (A,PAX,N)
COMP (A,N,PAX)
ξ = 10^-8 * S_0
L = 0
Part A
S_0^1 = E_0^2/D_0^2
E_0^2 = Σ_{i,j} |a_ij|^2 i ≠ j
D_0^2 = Σ_i |a_ii|^2
G
ROWSUM (A,N,MAX)
Part B
MAX = 1 ?
yes
no
INTERCH (A,B,N,MAX)
RESTORE1 (A,B,N)
ADJ (B,U,N,MAX)
RESTORE (U,B,N)
J = 0
F
K = 1
|A_2K-1,2K| < Z ?
no
C
yes
B


C
E
CALC (A,B,K)
Q = 0
TRANSF (T,A,K,Q)
PHI (D,T,K)
I = K + 1
1 > N/2
?
yes
no
MULM1 (C,T,A,I,K)
Q = 1
TRANSF (TT,A,I,Q)
MULM2 (B,C,TT,I,K)
I = I + 1
D


D
K = K + 1
K ≤ N/2 ?
yes
E
no
RESTORE1 (A,B,N)
ADDIT (A,N,S)
EIGEN (U,D,N)
S < ξ ?
yes
END
no
B
J = J + 1
J = N - 1 ?
yes
L = L + 1
G
no
L = L + 1
ADJUST (A,N)
EIGEN (U,PST,N)
F

If a matrix, A, does not satisfy this criterion then a factor, b, is determined as follows:

$$b = \max \left(|a_{ii}| + \sum |a_{ij}| \right) \qquad (i \neq j),$$

i.e., we form a diagonally dominant matrix B = A + bI (see flow chart, part A), then

$$\Lambda = WAW^t = W(B - bI)W^t = WBW^t - bI = \Lambda' = bI$$

where $\Lambda = \text{diag}\,(\lambda_i\,(A))$. Besides a 20 percent saving in time, a gain in the accuracy of the eigenvalues and the eigenvectors has been achieved.

5.8.2.1.2 Matrix Storage for QR-Algorithm

The QR method, developed by J. Francis [4], consists of two steps: (1) reduction of a given, real matrix to almost triangular form, and (2) application of QR transformation on this matrix. A program for this method was written for the B5500 to acquire a thorough understanding of the problems involved.

The elementary elimination method and Householder's method were tested for the first step. Though Householder's method, which uses unitary transformation, is stable as far as rounding off error accumulation is concerned, the elementary elimination method requires only half the number of multiplications that Householder's method requires. The elementary elimination requires $5/6\ n^3$ multiplications in contrast to $5/3\ n^3$ multiplications for Householder's method. The result of the test indicates no significant differences between the two methods for well conditioned problems--both in accuracy of eigenvalues and in the numbers of iterations required in finding the eigenvalues from the resulting triangular matrices.

Since the QR method, as it is now, is not suitable for parallel processing, the modified QR method (QPR, October, November, and December, 1968 [5]) is being considered. This method requires

$11/6\ n^3$ multiplications for one iteration, which corresponds to n/2 iterations in the ordinary QR method, compared with $5\ n^2$ for the classical method.

A study of the rate of convergence and the roundoff errors of the modified QR method is under way.

5.8.3 Pattern Matching Problem

During this quarter, a research effort was begun into the area of pattern matching. The problem is to check a source string, e.g., an English sentence, and locate a given matching pattern--a word. Such codes have been written on serial machines, and an attempt has been made to find a process to make effective use of the parallelism in ILLIAC IV. The method chosen will be referred to as the Two Phase Method. A program has been coded using ILLIAC IV assembler language, ASK/ASK II C; rough timing estimates have been obtained (about 80 times faster than the Burroughs 8500). A final stage of simulation has been reached using the ILLIAC IV simulator, SSK/SSK. More details will appear in an ILLIAC IV document.

5.9 Linear Programming

A significant portion of this quarter has been devoted to consideration of possible input and output processors for the linear programming system. Linear problems of ILLIAC IV dimensions require a sizeable amount of input data; the system should contain features which facilitate the specification (input) of these large models by the user. In addition, the conversion, pre- and post-processing of these data (outside the solution routines), consumes a substantial amount of the computer run time for the problem. Thus, the input and preprocessing facilities are an important part of a large linear programming system. The LPS preprocessor design effort will continue to interact with the development of sophisticated, flexible (user) input systems.

The investigation of the Gradient Projection method as a suitable optimization technique for large linear and nonlinear problems

was concluded this quarter. Results appear in "A Nonlinear Programming Algorithm for an Array Computer" [6], and in "Gradient Projection Method for Linear Programming" [7].

5.10 Long Codes

In order to evaluate the algorithms developed for the identification of dynamic systems, a set of programs will be developed to model a dynamic system and produce a stream of observation vectors to be manipulated by the various identification programs to be tested.

At each time step, a new system state vector is produced using the previous state vector and a predetermined transition matrix. Time-varying systems may be modeled by using a different transition matrix at each time step. Initial studies will concentrate on constant-parameter systems, where an invariant transition matrix is used. Noise vectors may be added directly to the system state vectors or to the observation vectors, which are obtained by pre-multiplying the state vectors by a predetermined observation matrix (or matrices if a time-varying system is to be modeled).

A separate noise generator program produces vectors whose elements are random variables having a Gaussian distribution with any specified covariance.

The noise generator program now has the capability to produce noise vectors having a covariance matrix equal to a scalar multiplied by an identity matrix. Also, the routines to produce the state vectors and observation vectors are essentially complete.

After the noise generator program is extended to allow more general covariance matrix specifications, and when routines, such as matrix inversion--that are used by most identification algorithms--are coded, various identification processes will be programmed and evaluated against published results.

5.11 Radar Data Processing

The Fast Fourier Transform (FFT) subroutines to handle data points (ranging from 8 to 4096) have been coded. Several parts of the subroutines have been completely debugged; however, debugging has been slow due to the inaccessibility of the B5500 computer and to the requirements of personnel working on higher priority tasks. Several new improvements have been investigated and are being incorporated into the present programs. Another routine for handling different data structures is being investigated and may be programmed as part of the routines.

Effort from this group has been applied to the improvement of 32-bit "higher" level languages for the ILLIAC IV. Changes to the GLYPNIR language, to facilitate using this language on 32-bit data structure, are being investigated. Also, the requirements for the 32-bit data handling in the layout of new languages is being investigated. The Kalman Filter Tracking Program [8] which previously was completely coded in assembly language, debugged, and executed on the simulator, has been recoded in the GLYPNIR language. The program was used to evaluate what 32-bit capability is missing in GLYPNIR and to obtain an idea of the efficiency of the higher level language on this type of problem.

5.12 Seismic Signal Processing

Two programs, autocorrelation and cross correlation, both basic requirements for a signal processing system, have been coded in ASK and are being debugged on the ILLIAC IV simulator.

Both programs are written in 32-bit and 64-bit floating point mode, using the same algorithm in each mode. Because the seismic data is real and usually contains 8-13 significant bits, the 32-bit mode allows the simultaneous processing of two data streams; whereas, the 64-bit mode provides a capability for those users whose data requires a larger word size. After debugging, the programs will be documented and added to the program library for ILLIAC IV.

5.13 Graphics

Investigations of equipment for use in the areas of interactive graphics, as well as microfilm and movie recording of graphic and alpha-numeric records, have been in progress.

Contacts with the user community have been made in order to evaluate the Project's requirements--present and future--for this type of equipment. Discussions have been held with the Project's operating system group involved in data communications in order to integrate this particular I/O channel into the system. Vendors have been approached and we have learned of the options available to us in the existing market.

At this time, we expect to understand our requirements and the options available to us on the market well enough to request a price quotation sometime in early February, with delivery of equipment anticipated in the Fall of 1970.

5.14 ILLIAC IV Education

5.14.1 CS 491-D

The graduate course in Computer Science, "Architecture, Application and Languages for a Parallel Computer," terminated this quarter. Based on the feedback from the students we will concentrate more heavily on programming languages next semester, particularly in the Assembly Language (ASK). The course will be numbered CS 491-E for the coming semester; the course outline is as follows:

I.	Hardware		6 classes
II.	Operating System		1 class
III.	Programming Languages		17 classes
		ASK	6 classes
		GLYPNIR	5 classes
		FORTRAN	4 classes
		Storage Schemes	2 classes
IV.	Applications		5 classes

5.14.2 Training Programs

A series of one-day seminars presenting an overview of ILLIAC will be offered monthly, starting in late February. The seminar will be primarily for orientation of new project personnel but will also act as an introduction of the machine to University personnel and other potential ILLIAC users. Following is a tentative outline of the seminar:

Algol and B5500	9:00 - 10:00 AM
Hardware	10:00 - noon
Instruction set (general)	1:00 - 2:00 PM
Available software	3:00 - 4:00 PM
Problem types and solutions	4:00 - 5:00 PM

In addition, more comprehensive follow-up courses will be offered in any specific area (ASK, GLYPNIR, etc.) if enough people are interested.

5.14.3 Documentation

Currently ACM (Association for Computing Machinery) category codes are being assigned to all ILLIAC IV documents. In the near future, a bibliography of all ILLIAC documents (sorted by ACM category code) will be mailed to all people currently on our mailing lists. Moreover, the FOURUM and Research Document mailing lists will be combined and all ILLIAC IV documents generated within and without the ILLIAC IV project at the University of Illinois will be assigned ACM codes and distributed through FOURUM.

5.14.4 ILLIAC IV Textbook

Work continues on the text which should be ready toward the end of the third quarter of 1970.

5.15 Administration and Services

An administrative assistant was hired in mid-December to establish a Project Business Office (PBO); thus, future reports will contain more information regarding the business operation of the project.

Bids for the construction of the Center for Advanced Computation building were received and approved by the University of Illinois Board of Trustees; a contractor has been selected, and construction of the building has started. The expected date of completion is late summer or early fall of 1970.

One of the initial steps taken by the PBO was to establish a discrete mailing address, as follows:

University of Illinois
ILLIAC IV Project
168 Engineering Research Laboratory
Urbana, Illinois 61801

At the present time, the University architect is working with the contractor in preparing bids for the electrical and mechanical systems for the Center for Advanced Computation. Burroughs is concurrently gathering similar material for bidding on the Environmental Control System of the Center.

Studies are under way to determine the need of an automatic fire extinguishing system on the computer floor and the machine room. This is being accomplished through consultation with the University architect, the University safety officer, and Burroughs Corporation.

REFERENCES

[1] Budnik, P., and Kuck, D. J., "A TRANQUIL Programming Primer," ILLIAC IV Document No. 236, DCS File No. 816, (December 10, 1969).

[2] Kuck, D., and Sameh, A., "Parallel Computation of Symmetric Matrix Eigenvalues." Unpublished.

[3] Sameh, A., and Han, L., "Eigen-Value Problems," ILLIAC IV Document No. 182, DCS Report No. 258, (April 4, 1968).

[4] Francis, J., "The QR Transformation, Parts I and II," Computer Journal, 4, 1961, pp. 265-271; 1962, pp. 332-345.

[5] ILLIAC IV Quarterly Progress Report, October, November, and December, 1968. ILLIAC IV Document No. 216, DCS Report No. 316. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

[6] Mulvey, J. M., "A Nonlinear Programming Algorithm for an Array Computer," DCS Report No. 357. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

[7] Yamamoto, T., and Lermit, J., "Gradient Projection Method for Linear Programming," ILLIAC IV Document No. 234, DCS File No. 820, (January 21, 1970).

[8] Stevens, J. E., Jr., "A Kalman-Filter Tracking Program for ILLIAC IV," ILLIAC IV Document No. 222, DCS File No. 804, (August 13, 1969).

THESES

Goddard, David M. "Weather Analysis on a Parallel Computer." Master's thesis, DCS Report No. 365. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Grothe, David M. "A Macro-Assembler for ILLIAC IV." Master's thesis, DCS Report No. 364. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Machado, Nelson C. "ISL--A Semantics Language for a Translator Writing System." Master's thesis, DCS Report No. 367. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Mulvey, John M. "A Nonlinear Programming Algorithm for an Array Computer." Master's thesis, DCS Report No. 357. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

Pavis, Denise C. "ICL: A Control Language for ILLIAC IV." Master's thesis, DCS Report No. 356. Urbana, Illinois: Department of Computer Science, University of Illinois, 1969.

DOCUMENTS

Budnik, P., and Kuck, D. J. "A TRANQUIL Programming Primer." ILLIAC IV Document No. 236, DCS File No. 816, (December 10, 1969).

Northcote, R. S. "Some Software Considerations in Utilization of a Network of Computers." ILLIAC IV Document No. 232, DCS File No. 815, (November 21, 1969).

Yasui, T. "Double Precision Arithmetic Routine for ILLIAC IV." ILLIAC IV Document No. 228, DCS File No. 813, (October 8, 1969).

6. NUMERICAL METHODS, COMPUTER ARITHMETIC AND ARTIFICIAL LANGUAGES

(Supported in part by the National Science Foundation under Grant No. NSF-GJ-217.)

6.1 Computerized Mathematics

Our results concerning the effects of eliminating tautologies on resolution based proof procedures was completed and made into a file number.* However, our results are subsumed by two articles already sent to publishers, so it was decided not to publish our results.

Our study of higher order logic is continuing, especially in the area of model theory.

(L. J. Henschen)

6.2 Numerical Solution of Singular Integral Equations

Investigations into the conditions on the integrand necessary for the Cauchy Principal Value to exist have led to the concept of the smoothness of functions and orders of infinity of functions as expressed by Hardy's Logarithmico-exponential functions. Using such functions as bounds on the modulus of continuity for a given function, it is possible to build up a structure of smooth functions, in order to determine the question of integrability in this sense. Although the problem of the slowness with which the modulus of continuity tends to zero being unbounded remains, this more elaborate structure permits a definite classification of the allowable functions, and hence of the function spaces we must work in, in order to solve integral equations involving Cauchy Principal Value integrals. The work on the above mentioned structure is currently being written.

(A. McInnes)

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* Henschen, L. J., "Resolution, Merging, Set of Support, and Tautologies," Department of Computer Science, University of Illinois, Urbana, Illinois 61801, File No. 817, December, 1969.

6.3 Study of Methods of Selection of Quotient Digits During Digital Division

For the class of division techniques being studied, it is possible to select quotient digits based upon an estimate of the divisor and shifted partial remainder. The quotient selection mechanism is itself a low-precision division structure (a "model division".)

In previous progress reports, programs were described which produce minimum cost, two-level, sum-of-products definitions of a table look-up model division. During the past quarter these programs were used to estimate the cost of various structures. The design variables include such items as radix, maximum quotient digit value, and the maximum error in the estimates of the divisor and partial remainder,

Based upon theoretical work and insight gained through computer runs, an equation for directly predicting the cost as a function of design parameters was proposed.

The experimental aspects of this present study are largely complete and a thesis describing the work is now being written.

(D. E. Atkins)

6.4 Automatic Function Generation

During this quarter, the basic research was essentially completed; some minor details remain. The simulation code was completed and a statistically significant sample of 2^{18} pseudo-random operands was tested. The test indicates that the theoretically predicted asymptotic results are correct. A study of implementation of the algorithms shows that the entire set can be implemented with reasonable cost because the hardware required by each algorithm is essentially the same. The control, of course, becomes significantly more complicated as more functions are included in the set.

(B. G. De Lugish)

6.5 NUCLEOL

During this quarter, a thesis* was written and submitted for publication. A summary follows:

> A formal definition of a very general class of tree transformations and description of the implementation of this system in terms of the list processing language NUCLEOL.

(K. Maruyama, J. Nievergelt)

6.6 Graph Algorithm Research

The GASP Manual was completed for publication in this quarterly progress report.

Efficiency analysis was begun on several algorithms for generating all spanning trees in a graph.

(S. Chase)

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* Maruyama, K., "A Tree Transformation System Based on NUCLEOL," submitted as partial fulfillment for the Master of Science degree in Computer Science, 1969. (Also Department of Computer Science Report No. 376, to be published.)

6.7 GASP Manual

6.7.1 Purposes of GASP

The main purpose of the Graph Algorithm Software Package is to allow programmers of graph algorithms to code programs in a natural and machine independent way. Because operations are expressed in a language of graph and set terms, the programs will be easy to follow and estimates of the amount of computation will be easier to compute. Comparisons among different algorithms for the same problem will be much easier using GASP because it is easy to generate programs from their description in conventional graph-theoretic terms. Moreover, some tallies on the amount of computation are provided by GASP.

The logical structure of GASP makes it possible to change representations with relatively little change in programs. A few low-level routines would have to be rewritten, but the higher level programs would not.

There have been other systems developed for graph algorithms, each with a different emphasis. These are described in the following references:

[1] R. C. Read, C. King, C. C. Cadogan, P. Morris. "The Application of Digital Computer Techniques to the Study of Graph Theoretical and Related Combinatorial Problems", Scientific Report, Computing Centre, University of the West Indies, Mona, Kingston 7, Jamaica.

[2] R. Hart. "HINT: A Graph Processing Language", Research Report, Computer Institute for Social Science Research, Michigan State University, East Lansing. February, 1969.

[3] D. P. Friedman, D. C. Dickson, J. J. Fraser, T. W. Pratt. "GRASPE 1.5 - A Graph Processor and its Application", University of Houston Report RS 1-69, August, 1969.

[4] M. W. Wolfberg. "An Interactive Graph Theory System", Moore School Report No. 69-25, University of Pennsylvania, Philadelphia, June, 1969.

6.7.2 Basic Concepts and Terminology

6.7.2.1 Data Types

6.7.2.1.1 An integer has the usual definition.

6.7.2.1.2 A character string is a fixed-length string of characters.

6.7.2.1.3 A truth value is a variable which can take on one of the two values: yes or no.

6.7.2.1.4 A name references an object (see below).

6.7.2.1.5 An object is a conglomeration consisting of one integer, one character string, three names, and (most important) one set. A set can exist only as part of an object. There are two types of objects: restricted and unrestricted. The only elements which can belong to a set are unrestricted objects.

6.7.2.2 Definitions and Assignments

GASP objects are available to the programmer only through one level of indirect addressing. The programmer deals with names which refer to objects which have values. This relationship (shown in Figure 1) is very important for the understanding of GASP.

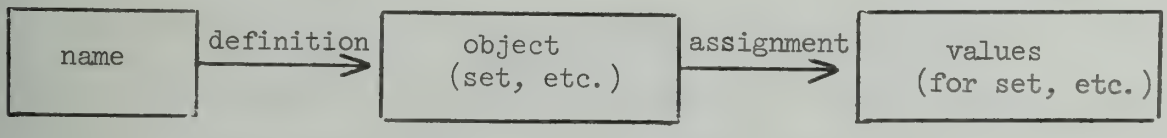


Figure 1

In order to distinguish one level from the other, we will use two sets of words. A name is defined if it references an existing object, otherwise it is undefined. A name may change its definition; that is, it can be made to refer to a different object. The number of

names referring to an object may vary from zero to any reasonable positive integer.

When the contents of a set is changed, we say the set is assigned the new value. Also, the object involved is assigned a new value.

The main advantage of this indirect addressing scheme is that not all objects need to be accessed by permanent names. E.g., all objects in a set S may be made accessible by means of the statement $FOR (ALL, X, S), even if no object in S has previously been given a name. In this case, we regard the bound variable X as a name whose definition ranges over all the objects in the set S.

6.7.2.3 Graphs

A graph is represented as an object whose set contains the branches and nodes belonging to the graph. Each node and each branch is an unrestricted object. In this first implementation, the set associated with a branch is the set of two incident nodes; the set associated with a node is the set of all incident branches and adjacent nodes.

6.7.2.4 System Objects

GASP reserves a few restricted objects for special use.

6.7.2.4.1 NULLSET is a read-only object whose set is always empty.

6.7.2.4.2 AC is an object whose set holds intermediate values of set operations.

6.7.2.4.3 USED is the object whose set contains all currently active unrestricted objects.

6.7.2.4.4 NODES and BRANCHES are the objects whose sets contain all

nodes and branches (respectively) belonging to the union of all graphs.

6.7.2.5 GASP Statement Forms

GASP is an extension of PL/1 (through the use of the PL/1 Preprocessor). Thus any PL/1 statement could be considered a GASP statement. The 'pure' GASP statements fall into three categories.

6.7.2.5.1 PL/1 statements which declare or assign values to GASP data types.

6.7.2.5.2 GASP Procedure calls which constitute a complete statement starting with CALL (unless the procedure name begins with $) and ending with a semi-colon.

6.7.2.5.3 Type-functions where type is one of the following: name, integer, truth value. A type-function call can be inserted almost anywhere a 'type' variable is allowed.

6.7.3 The GASP Statements for Sets

6.7.3.1 Notation

In the instruction set that follows, the actual code that must appear (as spelled) is capitalized while arbitrary names used as arguments are not.

6.7.3.2 Declarations

GASP variables are declared just as regular PL/1 variables are declared. Conversion from terms in section 2 to actual program words is shown below.

Formal Description	Computer Code
name (and unrestricted object)	$NAME
integer	$INTEGER
character string	$CHAR

truth value	$BIT
restricted object	$MAXSET

Note: Declaring a name (or unrestricted object) does not define it. However, 'DCL name1 $MAXSET ;' will create a restricted object and that object will be the definition of name1. $MAXSET is the only declaration which cannot be factored; 'DCL (S1, S2) $MAXSET ;' would result in both names S1 and S2 referring to the same object.

6.7.3.3 Definitions

Names can be defined in three ways:

6.7.3.3.1 Restricted Objects

The statement DCL name1 $MAXSET ; explained in section 8.3.2 will define name1.

6.7.3.3.2 Unrestricted Objects

The procedure call

$ALLOC (uo) ;

will create (storage for) a new unrestricted object which will become the definition of the name uo (previously declared $NAME). Also the character string part of this object will be assigned the value 'uo'.

6.7.3.3.3 All objects

The statement

anyname = name-expression ;

will define (or redefine) the name anyname to refer to the object named by name-expression (name-expression can be either a previously defined name or an arbitrary expression which computes a name value).

6.7.3.4 Freeing of Storage

The storage taken up by an object can be freed as follows:

6.7.3.4.1 Unrestricted Objects

The procedure call

$KILL (uo) ;

will free the unrestricted object named uo and the name uo will become undefined.

6.7.3.4.2 Restricted Objects

The procedure call

CALL POP (ro) ;

will free the restricted object named ro and leave ro undefined.

6.7.3.5 Operations on Sets

6.7.3.5.1 Notation

Nearly all arguments will be defined names. In the following examples, those names beginning with 's' are to be considered as sets (of any object) and those beginning with 'e' should be considered as elements of sets ('e' names must refer to unrestricted objects). As is the case with most GASP operations, no names are changed by the instructions in this section.

6.7.3.5.2 Truth Value Functions

6.7.3.5.2.1 $IS-IN(e, s) answers

'does e belong to s?'.

6.7.3.5.2.2 $EQUALS(s1, s2) answers

'does set s1 = set s2?'.

6.7.3.5.2.3 $EMPTY-(s) is equivalent to

$EQUALS(s, NULLSET).

6.7.3.5.3 Procedure Calls

6.7.3.5.3.1 $STORES (sname, s_expression); will assign to the set named sname the value of the set named s_expression (which remains unchanged).

6.7.3.5.3.2 $CLEAR(s) ; is equivalent to

$STORES (s, NULLSET) ;

6.7.3.5.3.3 $CHANGES (s, elem, op) where

op = ADD or DELETE will add (delete) elem to (from) the set s. If this does not change the truth value of the expression "elem ϵ s", then it is a harmless waste of time.

6.7.3.5.3.4 $CSES (s, e) ; (Clear and Store Element in Set) assigns to s the value $\{e\}$.

6.7.3.5.4 Integer Functions

6.7.3.5.4.1 CARD(s) returns the integer number of elements belonging to s.

6.7.3.5.5 Name functions (Choice)

The functions in this section pick elements out of sets with varying side effects.

6.7.3.5.5.1 $ELEM_OF(s) will return the name of an object belonging to the set s. This statement should not be used unless it is known that s is not empty. The set s is unchanged by this instruction.

6.7.3.5.5.2 CAN_PIC (e, s) is a truth value function which will answer 'CAN one PICk an element from s?'. If set s is not empty, e will name an object belonging to s, which will then be deleted from s. If s is empty, e will be undefined.

6.7.3.5.5.3 ITH_EL (s, i) will return (without deleting) the i-th element

of the set s, where i is an integer. Since this depends on the arbitrary (but fixed) ordering of elements in the implementation of the set, it may not be useful to users.

6.7.3.5.5.4 RANDEL(s) will return a randomly chosen element from the set s, without deleting it.

6.7.3.5.6 Name Functions (Intermediate Results)

The name functions in this section all perform some operation on the input sets and store the result in the AC. The name returned is always AC. The input sets remain unchanged (unless one of them is AC).

6.7.3.5.6.1 UNION (s1, s2) takes the union of sets s1 and s2.

6.7.3.5.6.2 INTER (s1, s2) takes the intersection of sets s1 and s2.

6.7.3.5.6.3 COMPL (s) takes the complement of the set s with respect to the universal set of unrestricted objects.

6.7.3.5.6.4 DIFF (s1, s2) contains those objects belonging to s1 but not to s2.

6.7.3.5.6.5 SYMDIF (s1, s2) contains those objects belonging to exactly one of the sets s1 and s2 (exclusive or).

6.7.3.6 Saving Object Values

If the user wishes to save the value of an object ob (to be restored later on), he should use the procedure call

```
CALL PUSH (ob);
```

The values are restored with

```
CALL POP (ob) ;
```

For example, consider the following code:

1

CALL PUSH (ob);

2

———

———

———

3

CALL POP (ob);

4

———

———

———

The values (of all the parts) of the object named ob will be the same at points 1, 2, and 4 regardless of the values at point 3 . The definition of ob remains unchanged throughout.

As the words 'push' and 'pop' imply, any number of copies of an object may be saved in this way, and restored in the usual 'last in - first out' order. Implementation restrictions will limit the total number of pushes-pops active at any point during execution.

6.7.3.7 I/O

GASP does not aid the user in the input of sets. Output is aided by the procedure call

CALL PELEMSK (s);

(Print ELEMent and SKip to next line).

This will print the character string of the object s and the character string of all objects belonging to the set of s.

EXAMPLE:

```
DCL (S1, S2, E1, E2, E3, E4) $NAME;
$ALLOC (S1); $ALLOC (E1); $ALLOC (E2);
E3 = E1;  E4 = E2;  S2 = S1;
$CSES (S2, E3); $CHANGES (S2, E4, ADD);
CALL PELEMSK (S2); END;
```

would generate the output line

```
S1 = (E1, E2)
```

and skip to the next line.

Regular PL/1 I/O is available, of course, and GASP extends this to include the procedure call

```
$PUT (var-name);
```

which is like PUT DATA (var-name);

but with no restrictions on var-name.

The entire data base (of objects) can be dumped with the procedure call

```
CALL ABDUMP ;  .
```

6.7.3.8 Expanding Operations

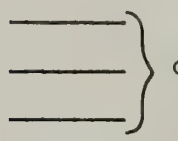
6.7.3.8.1 EXPAND2 (subr, set) is a name function which returns AC. Subr may be any name function (e.g., UNION, INTER, SYMDIF) which takes two names as arguments and performs a binary (usually associative and commutative) operation on their sets, returning the name of the set which holds the result. For example, if s = {e1, e2, e3}, then EXPAND2 (UNION, s) is equivalent to UNION (e1, UNION (e2, e3)). If s is empty then EXPAND2 (subr, s) is empty, and if s = {e1} then EXPAND2 (subr, s) = (the value of the set) e1.

6.7.3.8.2 CALL EXPAND1 (subr, set);

is a procedure call which can be used with any procedure subr which takes one name as input. EXPAND1 will call this routine with set as the argument, and then will call it with each object belonging to set as the argument. Useful choices for subr include PELEMSK, PUSH, and POP.

6.7.3.9 Loop Control

6.7.3.9.1 $FOR (quantifier, bound-variable, Loop-control-set);

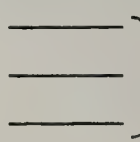


$END ;

allows code to be executed iteratively with each iteration having a different definition of the name bound-variable chosen from Loop-control-set. Quantifier may be any number, including ANY (equivalent to 1) and ALL (equivalent to cardinality of loop-control-set). Code will be executed minimum (quantifier, cardinality of loop-control-set) times. Loop-control-set may be any name or name function. Once the $FOR statement is executed, changing the loop-control-set will not affect or be affected by the actual loop control. The $FOR - $END pair is a PL/1 block, and bound-variable is automatically declared within this block (it need not be declared before).

The normal exit from a $FOR - $END section is to the next statement after $END. Any other jump outside must be expressed as GO_TO label ; .

6.7.3.9.2 $4ALLPAIRS (bv1, bv2, &cset)



$4APEND ;

is similar to the $FOR statement except that code is executed for all possible unordered choices of bound variables bv1 and bv2 subject to bv1, bv2 ε &cset and bv1 ≠ bv2. Abnormal exits must be through the statement GO_2 label;

6.7.4 The GASP Statements for Graphs

6.7.4.1 Truth Value Functions

6.7.4.1.1 INCIDENT (node1, branch 1)

answers 'is node1 incident to branch1?'.

6.7.4.1.2 ADJACENT (node1, node2)

answers 'is node1 adjacent to node2?'.

6.7.4.2 Simple Information Extraction

6.7.4.2.1 To get the set of adjacent nodes or incident branches of a given node1 or the set of incident nodes of a given branch1, use the following name functions (all return AC) :

SET_OF_INCIDENT (NODES, node1)

SET_OF_INCIDENT (BRANCHES, node1)

SET_OF_INCIDENT (NODES, branch1)

6.7.4.2.2 To get the set of nodes in graph1, use the name function (returns AC) $NOF(graph1). Similarly, the branches of graph1 are obtained by $BOF(graph1).

6.7.4.2.3 To get the two endpoints of branch in graph, use the procedure call

CALL GET_BAN (branch, endpt1, endpt2, graph) ;

6.7.4.3 Advanced Graph Operations

6.7.4.3.1 Node BOUNDary. NBOUND (nodeset, graph) is a name function

which returns (AC) the set of all nodes of graph which do not belong to nodeset but are adjacent to at least one node belonging to nodeset.

6.7.4.3.2 Branch BOUNDary. BBOUND (nodeset, graph) is a name function which returns (AC) the set of all branches of graph which have exactly one endpoint belonging to nodeset.

6.7.4.3.3 INTernal BrANcheS. CALL INTBANS (ioset, graph) ; is a procedure call which returns with ioset assigned the value of the subset of branches of graph which have both endpoints belonging to ioset (a set of nodes at input time).

6.7.4.3.4 DISTance. DIST (node1, node2, graph) is an integer function which returns the distance from node1 to node2 in graph.

6.7.4.3.5 COlLAPSe. CALL COLAPS (branch1, graph) ; is a procedure call which changes graph by merging the endpoints of branch1 into a single node and removing any branches connecting those endpoints (such as branch1).

6.7.4.3.6 DELete BrANch. CALL DELBAN (branch, graph) ; is a procedure call which deletes all trace of branch from graph.

6.7.4.3.7 DELete NODe. CALL DELNOD (node, graph) ; is a procedure call which deletes node and all of its incident branches from graph.

6.7.4.4 Graph I/O

6.7.4.4.1 Input. CALL READGR (graph) ; is the procedure call to input graph. The input format is a sequence of paths of node numbers (from 1 to the number of nodes). A new path is begun by a minus sign in front of the starting node. The entire sequence is terminated by a zero. READGR also will output graph (see below, 8.4.4.3).

EXAMPLE: Given the input sequence

1, 2, 4, -2, 3, 4, 1, 0,

READGR would create the graph shown in Figure 2.

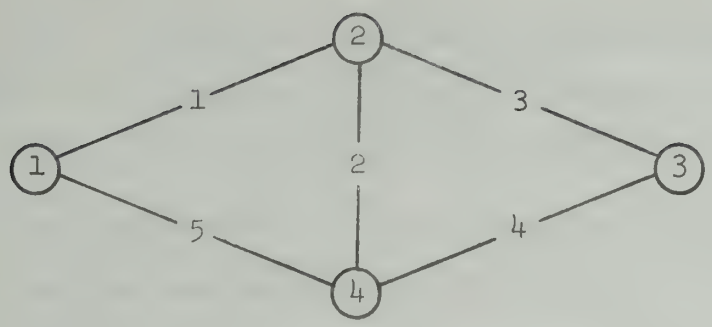


Figure 2.

6.7.4.4.2 DEFinition of BrANches dynamically.

CALL DEF_BAN (branch, endpoint1, endpoint2, graph) ; is the procedure call which will create a branch connecting endpoint1 and endpoint2 in graph.

6.7.4.4.3 Output. $PUTGRAPH (graph) ; is the procedure call which outputs graph as a set of nodes and branches. It is equivalent to CALL EXPAND1 (PELEMSK, graph) ; .

6.7.5 Implementation Details

6.7.5.1 Data Structure. A Universal SET (USET) contains all GASP objects. USET is a PL/1 structure subdivided into $TSIZE objects (level name is ELEMENT) of which $SIZE are unrestricted. The current system has $SIZE=64 and $TSIZE=127, but these can be changed easily. The set part (SSET) of an object is a bit string of length $SIZE (this is the only reason for restricted objects: an increase in the number of restricted objects increases the memory requirement only linearly; an increase in unrestricted objects increases memory requirements quadratically). The other parts of an object are CHARP (CHARacter string Part), INTP (INTeger Part), REFP (REFerence Part), RP_2 and RP_3 (Reference Part 2 and 3). PL/1 declarations for the various data types (c.f. section 8.3.2) are as follows: $CHAR = CHAR (8), $INTEGER = BIN FIXED (15), $NAME = BIN FIXED, and $BIT = BIT (1).

6.7.5.2 How GASP Works

6.7.5.2.1 Simple Procedures. GASP procedures which require only a line or so of code are translated by the PL/1 preprocessor. The identifiers which are translated by the GASP macros usually start with a '$'.

6.7.5.2.2 Advanced Procedures. Longer GASP procedures are incorporated into the programs as separate PL/1 procedures, and are always invoked by CALL procedure_name. The user has a choice of two methods which include these procedures in his program. The more efficient way is to include them as precompiled external procedures. The more flexible way is to have their source code inserted into the main program: this allows the user to set the limits $SIZE and $TSIZE to fit his needs.

6.7.5.3 Cost Parameters

Since the PL/1 preprocessor and PL/1 compiler are used, compilation time is usually large, run time is usually reasonable. For example, a typical program took 20 seconds to compile, 6 seconds to execute.

The core requirement for the basic GASP programs and data is around 120k bytes, a typical program might require a total of 150k bytes.

GASP macro definitions require 206 lines of PL/1 code, the source code of GASP procedures is around 240 lines.

6.7.5.4 Implementation Defects

6.7.5.4.1 When coding a binary set operation (e.g., 'UNION (S1,S2)'), one must make sure that at least one of the arguments is not AC.

6.7.5.4.2 'GO_TO' and 'GO_2' are precompiled into more than one PL/1 statement and therefore should not appear immediately after a 'THEN'.

6.7.6 Example

The following program illustrates the use of a few of the features of GASP and shows what control cards are needed. This program determines whether or not a graph is connected. The interesting code is between the labels 'CONNECT' and 'THE_END'.

```
/*  ( ID CARD )
/*FORMAT  PR,DDNAME=SYS1SG,TRAIN=PL1
//        EXEC  PL1LKGO,PARM.PL1=M,NOL,TIME.GO=(0,10)
//PL1.DD2 DD  UNIT=2314,VOL=SER=UIUSR1,
//             DSN=USER.P3396.SCMAC,DISP=(SHR,KEEP),
//             DCB=(RECFM=F,LRECL=80,BLKSIZE=80)
//PL1.SYSIN DD *
 EXAMPLE:PROC OPTIONS(MAIN);
   % INCLUDE DD2(SETS);
         $DCLSET(BRANCHES, 9);
         $DCLSET(NODES, 7);
   % INCLUDE DD2(GASP);
     DCL CONNECT ENTRY($NAME) RETURNS($BIT);
      DCL COMP $MAXSET, G $MAXSET, TEMP $MAXSET;
  CONNECT: PROC(G) $BIT;
      DCL G $NAME;
         $CSES(COMP,$ELEM_OF($NOF(G))) ;
      L: $STORES(TEMP,NBOUND(COMP)) ;
         IF $EMPTY_(TEMP) THEN RETURN ( NO ) ;
         $STORES (COMP, UNION(COMP, TEMP));
         IF ¬ $EQUALS(COMP, $NOF(G)) THEN GO TO L ;
         RETURN ( YES ) ;
     END CONNECT;
         ON ERROR SNAP  BEGIN;   ON ERROR GO TO THE_END;
                  CALL ABDUMP; GO TO THE_END;  END;
         $START
         CHARP(G) = 'GRAPH' ;
         CALL READGR(G);
         IF CONNECT(G) THEN PUT LIST ('CON');
      THE_END:  END EXAMPLE;
/*
//LKED.DD1 DD UNIT=2314,VOL=SER=UIUSR1,
//             DSN=USER.P3396.SCOBJ,DISP=SHR
//LKED.SYSIN DD *
   INCLUDE  DD1(OBJ1,OBJ2)
/*
//GO.SYSIN DD *
 1 2 3 4 1 3 -2 4 0
/*
********** OUTPUT:
 GRAPH=(B1,B2,B3,B4,B5,B6,N1,N2,N3,N4)
 B1=(N1,N2)
 B2=(N2,N3)
 B3=(N3,N4)
 B4=(N1,N4)
 B5=(N1,N3)
 B6=(N2,N4)
 N1=(B1,B4,B5,N2,N3,N4)
 N2=(B1,B2,B6,N1,N3,N4)
 N3=(B2,B3,B5,N1,N2,N4)
 N4=(B3,B4,B6,N1,N2,N3)
     CON
```

A Study of Implicit Iterative Procedure Due to H. L. Stone

The proof of convergence for the new implicit iterative method was completed. The proof consists of the following parts:

1. A + B is positive definite.
2. For a positive definite real symmetric matrix of the problem

$$m_0 \leq (Ax,x) \leq M_0$$

the iteration

$$(A+B)U_{n+1} = (A+B)U_n - \tau(AU_n - q)$$

converges if

$$0 < \tau < \frac{2}{M_0}$$

Work estimate: 10 n/iteration where A is an n x n matrix.

(A. Bracha)

6.8 Numerical Solution of Initial Value Problems in Ordinary Differential Equations

During this quarter, the numerical method of the following types

(i) Single step methods

(ii) Predictor-Corrector methods

(iii) Quadrature methods

have been studied for solving initial value problems of ordinary differential equations.

Using m-fold differentiation of the differential equation and the Felhberg transformation, the Runge-Kuttar type methods of order (m+5) and (m+6) with extended region of stability have been developed.

The stiffly stable methods based on Gear's criterian have been further examined. The results obtained will be published soon.

Firstly, in quadrature methods an attempt has been made to establish orthogonality relations of Jacobi polynomials with respect to line and area norms. The results obtained have appeared in DCL Report No. 369, December, 1969.

Secondly, the new discrete point orthogonality relations for Chebyshev polynomials have been obtained and applied to certain problems in numerical analysis. The above results will appear in DCL Report, January, 1970.

It is hoped that the results obtained in these reports will enable us to find a class of A-stable methods.

(M. K. Jain)

6.9 Quadrature Error Analysis

I have obtained errors of Gauss-Chebyshev quadratures[1] expressed in terms of the Chebyshev-Fourier coefficients of the integrand. These estimates are useful computationally since the Chebyshev coefficients can be calculated in terms of function-values through the well-known algorithm of Clenshaw. The methods used here are those of harmonic analysis, and the results are applicable to a wide class of integrands (continuous and of bounded variation on the interval of integration.) During the quarter, an attempt was made to obtain errors of the Gauss-Legendre, Lobatto and Radau quadratures in terms of the Chebyshev coefficients of the integrand. Here, due to the "complexity" of the formulas, to simplify matters, I restricted the discussion to analytic integrands, then using complex-variable methods, the errors were obtained expressed in terms of the Chebyshev-Fourier coefficients of the integrand[2].

I continued my analysis of Davis' method for estimating errors of rules of numerical approximation for analytic functions using Hilbert space techniques. In a joint report with Professor M. K. Jain[3], we have finalized our results. We have shown that the error estimates that result using Hilbert space techniques could be more simply obtained by use of Cauchy's integral formula. To reach the conclusion, we proved the line and area orthogonality of the Jacobi polynomials, on the contours and areas of certain confocal ellipses enclosing the interval on which approximation process is applied. It has been shown, for example, that the area measure of approximation leads to error norms which overestimate the errors than those measured by line integrals by nearly of the order of $n^{1/2}$. As a side result, relationships between real integrals, with Jacobi weight function, and line and double integrals are obtained.

(M. M. Chawla)

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[1] Chawla, M. M., "Estimation of Errors of Gauss-Chebyshev Quadratures," Comp. J., to be published.

[2] Chawla, M. M., "Asymptotic Gauss Quadrature Errors as Fourier Coefficients of the Integrand," submitted for publication.

[3] Chawla, M. M., and Jain, M. K., "Line and Area Orthogonality of Jacobi Polynomials," Department of Computer Science, University of Illinois, Urbana, Illinois 61801, Report No. 369, December 1969.

7. SWITCHING THEORY AND LOGICAL DESIGN

(Supported in part by the National Science Foundation under Grant No. NSF-GJ-503.)

One bit adder is designed by the implicit enumeration algorithm, using various types of gates. Inequalities are used in its problem formulation as integer programming problem. This work has been proceeded by Liu and Shiau. A computer program to design optimum networks for functions of 4 variables has been prepared by J. Culliney, using inequalities.

The branch-and-bound algorithm (no inequalities used) and the implicit enumeration algorithm (inequalities are explicitly used) have been compared in terms of efficiency for solving the design problem of optimum networks by T. Nakagawa.

C.R. Baugh started the final stage of writing a Ph.D. thesis on pseudo-threshold functions.

-- S. Muroga

The design of optimal AND-OR networks of 1-bit adder with double-rail logic was the main effort of this quarter.

At first, we found that at least 9 AND-OR gates are required for the 1-bit adder. The integer linear programming formulation for this 9-gate network needs more than three thousand inequalities which seem to be too many for the program to finish the problem in reasonable computation time. Therefore, effort was made in reducing the number of inequalities required. We noticed that more than one half of the total inequalities are of the nature of linearizing some pair of non-linear equalities as:

$$\beta = \alpha P \text{ and } \gamma = \alpha(1-P) \qquad (1)$$

Originally, four inequalities were used to represent (1) . However, after careful examination, two new inequalities which can also represent (1) were discovered. Replacing the four inequalities by the new two, we reduced the number of inequalities greatly. For the 9 AND-OR gate formulation, the number of inequalities was reduced by 1151. Furthermore, the two inequalities work more powerfully than the previous four, i.e. the two inequalities force some free variables to 1 or 0 when the previous four fail to.

In order to speed up the computation, the program was modified in the following way:

1. It seems very rare in an optimal AND-OR network to have two connected gates which are of the same type. Therefore whenever a new gate is connected to the network, the new gate is assumed to be of different type from that of the gate it is connected to. The other case, i.e. the two connected gates are of the same type, will be tried later. Thus, the optimal network will generally be obtained earlier during computation.
2. In addition to the desirability order (as in Report 293), a secondary criterion was incorporated, i.e. if two gate outputs have the same desirability order, then the one with minimum number of possible covers is selected to be covered first.
3. The non-zero coefficients of each inequality were re-ordered in descending order of magnitude instead of ascending order of column number. Therefore, some steps in checking inequalities can be skipped.

The computation time generally was reduced after each change. But the reduction was not drastic. Six different AND-OR networks for 1-bit adder was obtained. These networks require 9 gates and 21 connections and interconnections. Forty-five minutes was spent on 360/75, and the

program could neither prove that these networks are optimal nor find some better networks. The number of levels for these networks range from 3 to 5.

(T.K. Liu, L.E. Shiau)

In this quarter, I continued to attempt improvements to speed up Baugh's all-interconnection program for NOR networks (modified to solve problems of 4 variables). I finally decided on 2 programming gimmicks and 2 minor algorithm changes which, when implemented, might be able to achieve a somewhat significant increase in execution speed.

The first algorithm modification was due to C.R. Baugh who first suggested the possibility that we could by-pass the updating of the PS (positive sum) and NS (negative sum) in ILLIP for some inequalities during certain periods of the algorithm execution. (Namely, if $NS_i \geq 0$ immediately after the addition of some X_j to the partial solution, then do not update the PS or NS for row i until X_j is removed from the partial solution.) This improvement would only work for a problem type in which many variables are forced to certain values before the program selects some variable and assigns it a value which is not forced (i.e., on the average, each consecutive pair of non-underlined variables in the partial solution is separated by many underlined variables).

The second algorithm change is to remove a variable X_j from the partial solution as soon as an infeasible inequality is found, and readjust all the PS, NS values that had just been set prior to this discovery. Presently, even when an infeasibility is detected, the algorithm continues to update PS, NS values for all the inequalities that

contain X_j, and then it must (because of the infeasibility) go back and undo all the PS, NS changes it had just made.

During the next quarter, we will use Baugh's all-interconnection NOR program to obtain optimum networks of NOR gates for a sampling of "typical" 4 variable functions which we hope will be representative (in solution time) of all the 4 variable functions.

(J. Culliney)

The investigation of the computational efficiency of DAVIDSON's algorithm for optimal logical circuits was continued.

An attempt was made to implement the best version of DAVIDSON's program on the IBM 360/75. Most of the implementation was completed.

Besides this version, a version which employs certain simplified schemes for the algorithm was developed. This program obtains optimal solutions for all functions of three variables. (80 P-equivalence classes except the following three trivial equivalence classes, 0, 1, and x) in less than one minute.

(T. Nakagawa)

8. SOUPAC SECTION

(Statistically Oriented Users Programming and Consulting)

The SOUPAC consultants were active during the Fall of 1969 with seminars and lectures, new programs and our manual, as well as our usual consulting activities.

SOUPAC consultants gave lectures for the Biometrics Club (December 4th), the Mathematics Department (October 7th), Marketing 473 (November 17th), and Physical Education 451 (November 20th). They also participated extensively in the Survey Research Laboratory seminars (3 lectures and 3 discussion periods from October 30th to November 20th). Plans to have our own seminars on the use of SOUPAC beginning in February developed as a result of the intense interest in SOUPAC. SOUPAC consultants Joseph Kolman, Richard Montanelli, Robert Fleck, Secil Tuncalp, and Joan Mills participated in the lectures.

QUADRATIC PROGRAMMING, UNRESTRICTED MAXIMUM LIKELIHOOD FACTOR ANALYSIS, ECONOMETRICS, and RANDOM NUMBER GENERATOR are all functioning programs. PAIRED COMPARISONS and THREE STAGE LEAST SQUARES ESTIMATION should be ready soon. And the modification of the IBM SORT facility so that it can handle SOUPAC data sets neared completion. A catalogued procedure called SOUP, designed to save overhead for small users of SOUPAC programs (using 5 or fewer sequential data sets) was introduced. Soon to be released for general use is a facility to repeat designated section of SOUPAC code. The facility, to be controlled by a #REPEAT prolog card, should be written up in the January revision of the manual.

In December the SOUPAC Manual of Program Descriptions went to press to be released for the first time as a DCS report.

Joan A. Mills
Research Programmer

9. IBM SYSTEM/360 SERVICE

(Supported in part by the National Science Foundation under Grant No. NSF-GP-7634.)

9.1 Log Summaries

Table I - IBM 360/50-75
Summary of Use
October, 1969

Scheduled Engineering	15:40:00	
Unscheduled Engineering	5:40:00	
Idle	1:50:00	
	Subtotal	23:10:00
Batch	655:30:00	
System Maintenance and Development	65:20:00	
	Total	744:00:00

Table II - IBM 360/50-75
Summary of Errors
October, 1969

1501 Card Reader		3
2701 Data Adapter Unit		1
1052 Typewriter		1
	Total	5

TABLE III OCTOBER 1969

CENTISECONDS--360/75 PROCESSOR TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	515	117	632	599789	23062	622851
ACCY	1671	23	1694	492433	17885	510318
ADV	0	12	12	0	31407	31407
AGE	333	299	632	629715	311775	941490
AGEC	113	225	338	36176	660110	696286
AGRON	763	136	899	370865	191106	561971
ANS	0	86	86	0	50860	50860
ARCH	8	0	8	376	0	376
ASTR	0	128	128	0	145551	145551
BADM	22	0	22	31532	0	31532
BINRES	0	56	56	0	137742	137742
BIOPH	0	8	8	0	816	816
BOT	0	10	10	0	4132	4132
CE	1165	1328	2493	1144867	2496929	3641796
CERL	0	42	42	0	34952	34952
CEUSA	0	48	48	0	38992	38992
CHE	486	1459	1945	889827	6234607	7124434
CIRCE	0	12	12	0	21062	21062
CRC	0	42	42	0	122574	122574
CSL	0	81	81	0	108563	108563
DATLOG	0	3	3	0	745	745
DCS	15764	583	16347	4683325	1834778	6518103
DS	0	163	163	0	168784	168784
DUE	0	19	19	0	22419	22419
ECON	19	76	95	13924	52623	66547
ED	12	148	160	50793	245121	295914
EDADM	0	45	45	0	108150	108150
EDPSY	665	24	689	196863	7732	204595
EE	741	679	1420	258448	1575651	1834099
ENGADM	0	174	174	0	460481	460481
ENGCST	0	82	82	0	453091	453091
ENGH	534	0	534	166791	0	166791
FIN	111	43	154	474472	256733	731205
FOR	0	5	5	0	2507	2507
FT	0	68	68	0	40981	40981
GENE	366	1	367	136337	103	136440
GEOG	98	105	203	46117	94255	140372
GEOL	22	108	130	11682	273290	284972
HACDMH	0	2	2	0	28605	28605
HEC	0	13	13	0	8521	8521
HED	0	30	30	0	155438	155438
HORT	0	37	37	0	34920	34920
ICR	0	278	278	0	239532	239532
IE	1	0	1	1	0	1
ILLCF	0	7	7	0	805	805
ILR	0	113	113	0	107933	107933
IREC	0	12	12	0	8030	8030
LIBS	0	9	9	0	10564	10564
MATH	23	42	65	18519	88630	107149
MATRL	0	634	634	0	2253024	2253024
MCBIO	0	7	7	0	2621	2621
ME	1461	242	1703	338921	1476329	1815250
MKTG	0	34	34	0	21035	21035

MUSIC	77	46	123	436152	71568	507720
NUCE	28	290	318	8274	537870	546144
OIR	0	361	361	0	567606	567606
ORME	C	6	6	0	634	634
PEM	C	60	60	0	54209	54209
PHYB	C	81	81	0	188784	188784
PHYCS	39	1106	1145	3702	1159424	1163126
PHYSL	0	35	35	0	12860	12860
PHYX	0	247	247	0	1147876	1147876
POLS	29	84	113	39762	57400	97162
PROVST	C	16	16	0	26955	26955
PSYCH	177	721	898	234180	2509891	2744071
REC	44	11	55	192826	28438	221264
SCONS	C	5	5	0	36600	36600
SCS	0	11	11	0	112320	112320
SGS	0	253	253	0	278267	278267
SOC	20	46	66	4216	186727	190943
SOCW	20	1	21	174683	9	174692
SPAN	0	21	21	0	22167	22167
SPCH	0	5	5	0	496	496
SPED	C	28	28	0	9428	9428
SRL	54	75	129	13792	508458	522250
SWS	0	802	802	0	1488594	1488594
TAM	184	100	284	311942	1189841	1501783
UOSCR	0	39	39	0	122091	122091
USGS	0	11	11	0	664	664
VPP	C	18	18	0	701	701
VTED	C	19	19	0	59870	59870
WPGU	C	2	2	0	3603	3603
ZOOL	C	91	91	0	1027736	1027736
SUBTOTAL	25565	12489	38054	12011302	32076643	44087945
DCSSYS[3]	0	3361	3361	0	6287988	6287988
OVRHED[4]	0	1	1	0	0	0
REFUND[5]	0	235	235	0	1354480	1354480
UADP[6]	0	62	62	0	614829	614829
XDCS[7][8]	C	94	94	0	58964	58964
XMAINT	C	67	67	0	86604	86604
XSSS[9]	0	922	922	0	1750607	1750607
TOTAL	25565	17231	42796	12011302	40479508	42230115

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

TABLE III OCTOBER 1969

INPUT/OUTPUT REQUESTS--360/75

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	477	117	594	237233	32798	270031
ACCY	1638	22	1660	296591	35911	332502
ADV	0	12	12	0	43400	43400
AGE	331	299	630	388215	328252	716467
AGEC	113	223	336	95212	716280	811492
AGRON	760	134	894	353760	140851	494611
ANS	0	83	83	0	56262	56262
ARCH	8	0	8	1611	0	1611
ASTR	0	127	127	0	97469	97469
BADM	22	0	22	19736	0	19736
BINRES	0	56	56	0	116052	116052
BIOPH	0	8	8	0	4247	4247
BOT	0	10	10	0	8796	8796
CE	1150	1283	2433	616484	1465794	2082278
CERL	0	41	41	0	75555	75555
CEUSA	0	48	48	0	31176	31176
CHE	482	1424	1906	217618	1715827	1933445
CIRCE	0	9	9	0	13041	13041
CRC	0	41	41	0	152509	152509
CSL	0	78	78	0	133706	133706
DATLOG	0	3	3	0	1011	1011
DCS	15737	570	16307	3018498	855024	3873522
DS	0	160	160	0	127283	127283
DUE	0	19	19	0	14167	14167
ECON	17	76	93	5062	88837	93899
ED	12	141	153	19085	214692	233777
EDADM	0	40	40	0	191095	191095
EDPSY	627	24	651	65568	10542	76110
EE	718	672	1390	266042	596075	862117
ENGADM	0	170	170	0	645417	645417
ENGCST	0	81	81	0	219329	219329
ENGH	533	0	533	218026	0	218026
FIN	100	43	143	79372	281117	360489
FOR	0	5	5	0	4948	4948
FT	0	66	66	0	50138	50138
GENE	364	1	365	140675	297	140972
GEOG	98	104	202	109626	64267	173893
GEOL	20	107	127	20227	229711	249938
HACDMH	0	2	2	0	39809	39809
HEC	0	13	13	0	11799	11799
HED	0	28	28	0	227407	227407
HORT	0	37	37	0	45241	45241
ICR	0	266	266	0	256585	256585
IE	1	0	1	0	0	0
ILLCF	0	4	4	0	1725	1725
ILR	0	113	113	0	129248	129248
IREC	0	12	12	0	9007	9007
LIBS	0	9	9	0	14831	14831
MATH	23	40	63	12558	24981	37539
MATRL	0	631	631	0	606614	606614
MCBIO	0	7	7	0	3268	3268
ME	1458	241	1699	553198	201063	754261
MKTG	0	28	28	0	19394	19394

MUSIC	76	46	122	108732	134366	243098
NUCE	28	282	310	21108	379891	400999
OIR	0	360	360	0	565511	565511
ORME	0	6	6	0	382	382
PEM	0	60	60	0	62624	62624
PHYB	0	80	80	0	86948	86948
PHYCS	39	1085	1124	10392	746977	757369
PHYSL	0	32	32	0	10695	10695
PHYX	0	243	243	0	664485	664485
POLS	29	84	113	24605	60848	85453
PROVST	0	16	16	0	51874	51874
PSYCH	170	702	872	76630	1114775	1191405
REC	44	11	55	374243	19399	393642
SCONS	0	5	5	0	19523	19523
SCS	0	9	9	0	20667	20667
SGS	0	251	251	0	290690	290690
SOC	20	45	65	5618	106240	111858
SOCW	20	0	20	220210	0	220210
SPAN	0	21	21	0	50018	50018
SPCH	0	5	5	0	241	241
SPED	0	28	28	0	24204	24204
SRL	54	74	128	18753	335156	353909
SWS	0	790	790	0	692800	692800
TAM	183	100	283	78314	96273	174587
UOSCR	0	38	38	0	153974	153974
USGS	0	11	11	0	1286	1286
VPP	0	17	17	0	1542	1542
VTED	0	19	19	0	12206	12206
WPGU	0	2	2	0	5066	5066
ZOOL	0	88	88	0	84286	84286
SUBTOTAL	25352	12238	37590	7673002	16145795	23818797
DCSSYS [3]	0	3276	3276	0	5770326	5770326
OVRHED [4]	0	1	1	0	0	0
REFUND [5]	0	218	218	0	301339	301339
UADP [6]	0	61	61	0	33101	33101
XDCS [7]	0	80	80	0	268305	268305
XMAINT [8]	0	66	66	0	358575	358575
XSSS [9]	0	922	922	0	603921	603921
TOTAL	25352	16862	42214	7673002	22894303	31154364

1 See list of departmental codes following
2 Training and Education
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TABLE III OCTOBER 1969

UNITS CHARGED--360/75

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	465	116	581	50282	2595	52877
ACCY	1629	22	1651	40754	3035	43789
ADV	0	12	12	0	5991	5991
AGE	329	298	627	46904	38339	85243
AGEC	113	221	334	6962	72716	79678
AGRON	760	134	894	32558	19009	51567
ANS	0	83	83	0	7351	7351
ARCH	8	0	8	108	0	108
ASTR	0	126	126	0	14874	14874
BADM	22	0	22	4122	0	4122
BINRES	0	56	56	0	14977	14977
BIOPH	0	8	8	0	154	154
BOT	0	10	10	0	604	604
CE	1141	1274	2415	102532	240371	342903
CERL	0	41	41	0	8302	8302
CEUSA	0	48	48	0	3807	3807
CHE	480	1418	1898	65733	403987	469720
CIRCE	0	9	9	0	2812	2812
CRC	0	41	41	0	21686	21686
CSL	0	78	78	0	17103	17103
DATLOG	0	3	3	0	70	70
DCS	15712	564	16276	392847	154533	547380
DS	0	160	160	0	18114	18114
DUE	0	19	19	0	3015	3015
ECON	17	76	93	1056	8736	9792
ED	12	139	151	5740	33316	39056
EDADM	0	39	39	0	17183	17183
EDPSY	632	24	656	17063	1501	18564
EE	717	661	1378	24124	110186	134310
ENGADM	0	169	169	0	58505	58505
ENGCST	0	81	81	0	31573	31573
ENGH	533	0	533	15675	0	15675
FIN	100	43	143	33951	39006	72957
FOR	0	5	5	0	373	373
FT	0	66	66	0	5038	5038
GENE	360	1	361	12070	16	12086
GEOG	98	104	202	9277	10077	19354
GEOL	20	107	127	1358	24780	26138
HACDMH	0	2	2	0	5652	5652
HEC	0	13	13	0	1672	1672
HED	0	29	29	0	31229	31229
HORT	0	37	37	0	4669	4669
ICR	0	261	261	0	30387	30387
IE	1	0	1	0	0	0
ILLCF	0	4	4	0	95	95
ILR	0	113	113	0	17365	17365
IREC	0	12	12	0	1032	1032
LIBS	0	9	9	0	2093	2093
MATH	23	40	63	1253	8097	9350
MATRL	0	623	623	0	144870	144870
MCBIO	0	7	7	0	236	236
ME	1455	241	1696	38126	87301	125427
MKTG	0	30	30	0	2631	2631

MUSIC	76	45	121	26711	10998	37709
NUCE	28	282	310	1523	59417	60940
OIR	0	336	336	0	68275	68275
ORME	0	6	6	0	81	81
PEM	0	60	60	0	9324	9324
PHYB	0	79	79	0	15217	15217
PHYCS	39	1058	1097	581	102166	102747
PHYSL	0	31	31	0	929	929
PHYX	0	243	243	0	124953	124953
PULS	29	82	111	4813	7056	11869
PROVST	0	16	16	0	6506	6506
PSYCH	170	702	872	21306	226166	247472
REC	44	11	55	44358	3949	48307
SCONS	0	5	5	0	4376	4376
SCS	0	9	9	0	10985	10985
SGS	0	251	251	0	32666	32666
SOC	20	45	65	804	24188	24992
SOCW	20	0	20	32624	0	32624
SPAN	0	20	20	0	2928	2928
SPCH	0	5	5	0	59	59
SPED	0	28	28	0	1358	1358
SRL	54	74	128	2667	64314	66981
SWS	0	785	785	0	127427	127427
TAM	183	99	282	20367	93431	113798
UOSCR	0	37	37	0	22421	22421
USGS	0	10	10	0	88	88
VPP	0	17	17	0	84	84
VTED	0	19	19	0	5864	5864
WPGU	0	2	2	0	351	351
ZOOL	0	88	88	0	57507	57507
SUBTOTAL	25290	12122	37412	1058249	2814148	3872397
DCSSYS[3]	0	3244	3244	0	721311	721311
OVRHED[4]	0	1	1	0	0	0
REFUND[5]	0	222	222	0	100912	100912
UADP[6]	0	61	61	0	27494	27494
XDCS[7]	0	77	77	0	16476	16476
XMAINT[8]	0	66	66	0	18117	18117
XSSS[9]	0	917	917	0	135252	135252
TOTAL	25290	16710	42000	1058249	3833710	4891959

1 See list of departmental codes following
2 Training and Education
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TABLE III OCTOBER 1969

SECONDS--1800 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGE	C	3	3	0	4552	4552
BIOPH	C	7	7	0	446	446
CON	C	3	3	0	30	30
E	C	19	19	0	7203	7203
MATRL	0	6	6	0	3746	3746
MUSIC	0	4	4	0	719	719
NUCE	C	5	5	0	1672	1672
SUBTOTAL	0	47	47	0	18368	18368
OCSSYS[3]	0	53	53	0	38054	38054
REFUND[4]	C	3	3	0	2100	2100
UDCS[5]	C	2	2	0	755	755
TOTAL	0	105	105	0	59277	59277

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 System Updating

Table I - IBM 360/20

Summary of Use

October, 1969

Scheduled Engineering	1:42
Unscheduled Engineering	4:30
Maintenance	7:40
Production	238:10
Idle	293:58
Total Time	546:00

Table II - 360/20

Summary of Machine Errors

October, 1969

2203 Printer	1
2560 MFCM	3
Total	4

TABLE III OCTOBER 1969

MINUTES--360/20 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	18	9	27	86	19	105
ACCY	17	0	17	26	0	26
ADV	C	2	2	0	28	28
AGE	11	41	52	178	368	546
AGEC	12	37	49	188	368	556
AGRON	23	14	37	35	94	129
ANS	2	16	18	13	77	90
ASTR	C	20	20	0	101	101
BADM	C	1	1	0	2	2
BINRES	C	2	2	0	9	9
CE	8	33	41	56	322	378
CERL	0	3	3	0	42	42
CHE	16	81	97	63	850	913
CIRCE	0	6	6	0	112	112
CRC	0	7	7	0	97	97
CSL	C	9	9	0	114	114
DCS	757	70	827	1328	460	1788
DS	C	14	14	0	50	50
ECCN	C	14	14	0	47	47
ED	7	19	26	39	248	287
EDADM	C	1	1	0	29	29
EDPSY	35	1	36	48	3	51
EE	10	42	52	16	358	374
ENGADM	0	9	9	0	27	27
ENGCST	C	9	9	0	42	42
ENGH	4	0	4	5	0	5
FIN	2	5	7	4	21	25
FT	0	2	2	0	5	5
GENE	10	0	10	26	0	26
GEOG	10	7	17	15	244	259
GEOL	2	19	21	15	245	260
HACDMH	C	1	1	0	29	29
HEC	C	2	2	0	51	51
HED	0	14	14	0	140	140
HORT	0	4	4	0	48	48
ICR	C	29	29	0	212	212
ILR	C	41	41	0	179	179
IREC	C	3	3	0	10	10
MATH	C	9	9	0	36	36
MATRL	C	42	42	0	216	216
ME	61	45	106	158	234	392
MKTG	C	7	7	0	10	10
MUSIC	6	15	21	15	170	185
NUCE	1	31	32	13	172	185
OIR	C	14	14	0	161	161
PEM	C	14	14	0	101	101
PERRIF	0	1	1	0	16	16
PHYB	0	8	8	0	16	16
PHYCS	C	45	45	0	217	217
PHYX	C	26	26	0	194	194
POLS	3	5	8	3	22	25
PROVST	0	17	17	0	185	185
PSYCH	8	92	100	14	1137	1151

REC	0	1	1	0	6	6
SCS	C	1	1	0	14	14
SGS	0	13	13	0	44	44
SOC	31	12	43	139	131	270
SRL	14	2	16	160	25	185
SWS	0	2	2	0	14	14
TAM	7	9	16	43	32	75
UOSCR	0	9	9	0	227	227
VTED	0	20	20	0	98	98
WPGU	C	4	4	0	25	25
ZOOL	0	6	6	0	23	23
SUBTOTAL	1075	1037	2112	2686	8577	11263
DCSSYS[3]	0	316	316	0	2511	2511
REFUND[4]	0	6	6	0	75	75
UADP[2]	C	9	9	0	32	32
XDCS[6]	C	8	8	0	53	53
XMAINT[7]	C	571	571	0	17556	17556
TOTAL	1075	1947	3022	2686	28804	31490

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 University Administrative Overhead Use
6 System Updating
7 System Maintenance

TABLE III OCTOBER 1969

MINUTES--SERVICE PROGRAMMING

EPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
GEC	0	3	3	0	1020	1020
E	0	2	2	0	345	345
HE	0	1	1	0	1500	1500
RC	0	1	1	0	300	300
T	0	3	3	0	540	540
EOG	0	3	3	0	555	555
ATRL	0	2	2	0	420	420
UBTOTAL	0	15	15	0	4680	4680
OTAL	0	15	15	0	4680	4680

See list of departmental codes following
Training and Education

TABLE III OCTOBER 1969

CARDS KEYPUNCHED

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
ACCY	2	2	4	400	1300	1700
ADV	0	2	2	0	1700	1700
AGE	0	3	3	0	1300	1300
AGEC	0	4	4	0	1400	1400
ANS	2	3	5	800	1300	2100
ASTR	0	1	1	0	2900	2900
BADM	0	1	1	0	600	600
CHE	0	2	2	0	1050	1050
CRC	0	49	49	0	8000	8000
DCS	10	10	20	2000	2900	4900
ED	0	3	3	0	300	300
EDPSY	2	2	4	200	200	400
EE	0	2	2	0	800	800
FIN	1	1	2	200	100	300
FT	0	5	5	0	1600	1600
GEOG	0	2	2	0	10900	10900
GEOL	1	0	1	250	0	250
HORT	0	1	1	0	400	400
MATRL	0	5	5	0	1650	1650
NUCE	0	1	1	0	100	100
PEM	0	4	4	0	2300	2300
PEW	0	2	2	0	3500	3500
PHYCS	0	3	3	0	800	800
PHYX	0	11	11	0	19300	19300
POLS	0	3	3	0	1100	1100
PROVST	0	4	4	0	2050	2050
PSYCH	0	2	2	0	1900	1900
REC	0	1	1	0	300	300
SOCW	1	0	1	300	0	300
VTED	0	1	1	0	200	200
ZOOL	0	1	1	0	500	500
SUBTOTAL	19	131	150	4150	70450	74600
DCSSYS[3]	0	59	59	0	27100	27100
XDCS[4]	0	1	1	0	700	700
TOTAL	19	191	210	4150	98250	102400

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Updating

Table I - IBM 360/50-75

Summary of Use

November, 1969

Scheduled Engineering	20:52:00	
Unscheduled Engineering	7:10:00	
Idle	7:50:00	
	Subtotal	35:52:00
Batch	602:47:00	
System Maintenance and Development	81:21:00	
	Total	720:00:00

Table II - IBM 360/50-75

Summary of Errors

November, 1969

Disk Drive - 50		1
	Total	1

TABLE III NOVEMBER 1969

CENTISECONDS--360/75 PROCESSOR TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	790	69	859	2018108	35839	2053947
ACCY	1093	45	1138	225183	41793	266976
ADV	0	36	36	0	19798	19798
AGE	62	193	255	118016	487116	605132
AGEC	689	139	828	168541	296905	465446
AGRON	549	178	727	90893	142140	233033
ANS	0	81	81	0	118643	118643
ARCH	33	0	33	18071	0	18071
ARL	0	16	16	0	14829	14829
ASTR	13	111	124	5039	190730	195769
BADM	63	26	89	98509	9368	107877
BECBSR	0	6	6	0	896	896
BINRES	0	14	14	0	21630	21630
BOT	0	4	4	0	1956	1956
CE	1897	1460	3357	1890090	2269782	4159872
CERL	0	26	26	0	28443	28443
CEUSA	0	12	12	0	15103	15103
CHE	699	1414	2113	299121	5448216	5747337
CIRCE	0	14	14	0	20864	20864
CRC	0	21	21	0	5239	5239
CSL	0	72	72	0	158978	158978
DATLOG	0	15	15	0	11145	11145
DCS	13364	474	13838	4871887	1082032	5953919
DS	32	99	131	1232	193886	195118
DUE	0	30	30	0	118897	118897
ECON	64	85	149	34633	95341	129974
ED	3	150	153	882	250976	251858
EDADM	0	38	38	0	275913	275913
EDPSY	433	3	436	112644	850	113494
EE	2529	800	3329	833528	1627661	2461189
ENGADM	0	197	197	0	509199	509199
ENGCST	0	81	81	0	402302	402302
ENGH	395	0	395	125264	0	125264
ENGLSH	0	2	2	0	0	0
FIN	367	2	369	1407504	3907	1411411
FT	0	49	49	0	35817	35817
GENE	165	9	174	38691	2134	40825
GEOG	140	66	206	389876	52025	441901
GEOL	84	135	219	57464	272924	330388
GRDCOL	0	6	6	0	11125	11125
HEC	0	2	2	0	3930	3930
HORT	0	23	23	0	14149	14149
ICR	0	395	395	0	594748	594748
IE	5	0	5	1195	0	1195
IGPA	0	17	17	0	23702	23702
ILLCF	0	1	1	0	20	20
ILR	0	33	33	0	16256	16256
IREC	0	1	1	0	430	430
LIBS	0	9	9	0	7100	7100
MATH	137	36	173	51893	55174	107067
MATRL	0	620	620	0	3500017	3500017
MCBIO	0	2	2	0	1257	1257
ME	2010	528	2538	636674	1260314	1896988

MKTG	C	67	67	0	43524	43524
MMPE	0	7	7	0	3404	3404
MUSIC	38	124	162	204213	443505	647718
NHS	C	4	4	0	1884	1884
NUCE	27	156	183	33959	648230	682189
OAC	0	13	13	0	3374	3374
OAS	0	33	33	0	65415	65415
OIR	0	148	148	0	332512	332512
PEM	C	98	98	0	119612	119612
PHYB	0	80	80	0	229669	229669
PHYCS	46	1794	1840	11862	1866847	1878709
PHYSL	C	42	42	0	12134	12134
PHYX	C	301	301	0	1459131	1459131
POLS	50	45	95	44830	23458	68288
PROVST	0	8	8	0	4783	4783
PSYCH	238	740	978	507931	3102545	3610476
REC	15	2	17	18790	12436	31226
SCONS	C	4	4	0	34224	34224
SCS	C	5	5	0	144729	144729
SGS	C	212	212	0	292814	292814
SOC	238	44	282	83702	39532	123234
SOCW	3	33	36	1083	42771	43854
SPCH	0	11	11	0	12259	12259
SPED	0	5	5	0	1551	1551
SRL	388	55	443	347814	200269	548083
SWS	0	996	996	0	1453751	1453751
TAM	377	81	458	693864	199016	892880
UICCMM	0	3	3	0	2438	2438
UOSCR	0	42	42	0	54981	54981
URPLAN	7	0	7	238	0	238
VPH	0	4	4	0	288	288
VPP	0	49	49	0	2242	2242
VTED	C	28	28	0	38356	38356
WPGU	0	10	10	0	39810	39810
ZOOL	0	102	102	0	-386	-386
SUBTOTAL	27043	13191	40234	15443224	30682607	46125831
OCSSYS [3]	0	3380	3380	0	7706511	7706511
OVRHED [4]	0	2	2	0	0	0
REFUND [5]	C	115	115	0	511801	511801
UADP [6]	0	43	43	0	20828	20828
XOCS [7]	0	43	43	0	22174	22174
XMAINT [8]	0	39	39	0	75048	75048
XSSS [9]	C	238	238	0	94065	94065
TOTAL	27043	17101	44144	15443224	39113034	54556258

1 See list of departmental codes following
2 Training and Education
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4 System Use in Excess of User Estimated Usage
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7 System Updating
8 System Maintenance
9 Special Short Shots

TABLE III NOVEMBER 1969

INPUT/OUTPUT REQUESTS--360/75

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	790	69	859	309631	70142	379773
ACCY	1093	45	1138	272760	82079	354839
ADV	0	36	36	0	15077	15077
AGE	62	193	255	61526	291120	352646
AGEC	689	139	828	537908	550058	1087966
AGRON	549	178	727	186420	154066	340486
ANS	0	81	81	0	78787	78787
ARCH	33	0	33	11453	0	11453
ARL	0	16	16	0	17656	17656
ASTR	13	111	124	3782	109587	113369
BADM	63	26	89	51078	16696	67774
BECBSR	0	6	6	0	1722	1722
BINRES	0	14	14	0	12764	12764
BOT	0	4	4	0	4067	4067
CE	1897	1460	3357	1346085	1121140	2467225
CERL	0	26	26	0	50207	50207
CEUSA	0	12	12	0	9267	9267
CHE	699	1416	2115	214668	1386047	1600715
CIRCE	0	14	14	0	22240	22240
CRC	0	21	21	0	6517	6517
CSL	0	72	72	0	129974	129974
DATLOG	0	15	15	0	14043	14043
DCS	13364	474	13838	3265216	505203	3770421
DS	32	99	131	871	90055	90926
DUE	0	30	30	0	23602	23602
ECON	64	85	149	31678	162960	194638
ED	3	150	153	2443	141583	144026
EDADM	0	38	38	0	132338	132338
EDPSY	433	3	436	88064	585	88649
EE	2529	800	3329	790655	827188	1617843
ENGADM	0	197	197	0	810345	810345
ENGCST	0	81	81	0	177594	177594
ENGH	395	0	395	133730	0	133730
ENGLSH	0	2	2	0	0	0
FIN	367	2	369	536542	4757	541299
FT	0	49	49	0	32906	32906
GENE	165	9	174	51583	3166	54749
GEOG	140	66	206	69490	29537	99027
GEOL	84	135	219	85543	187093	272636
GRDCOL	0	6	6	0	15374	15374
HEC	0	2	2	0	6681	6681
HORT	0	23	23	0	20777	20777
ICR	0	395	395	0	598086	598086
IE	5	0	5	1578	0	1578
IGPA	0	17	17	0	32646	32646
ILLCF	0	1	1	0	144	144
ILR	0	33	33	0	23901	23901
IREC	0	1	1	0	220	220
LIBS	0	9	9	0	8131	8131
MATH	137	36	173	56277	19171	75448
MATRL	0	620	620	0	552685	552685
MCBIO	0	2	2	0	1303	1303
ME	2010	530	2540	917253	368881	1286134

MKTG	0	67	67	0	41549	41549
MMPE	0	7	7	0	1518	1518
MUSIC	38	124	162	57957	316168	374125
NHS	0	4	4	0	1005	1005
NUCE	27	156	183	43156	237888	281044
OAC	0	13	13	0	2784	2784
OAS	0	33	33	0	37408	37408
OIR	0	148	148	0	260336	260336
PEM	0	98	98	0	93509	93509
PHYB	0	80	80	0	96958	96958
PHYCS	46	1794	1840	19819	1000284	1020103
PHYSL	0	42	42	0	8594	8594
PHYX	0	301	301	0	943742	943742
POLS	50	45	95	59664	31252	90916
PROVST	0	8	8	0	8158	8158
PSYCH	238	740	978	332710	1215643	1548353
REC	15	2	17	8189	7392	15581
SCONS	0	4	4	0	15020	15020
SCS	0	5	5	0	13750	13750
SGS	0	212	212	0	183963	183963
SOC	238	44	282	58716	33787	92503
SOCW	3	33	36	463	35882	36345
SPCH	0	11	11	0	1134	1134
SPED	0	5	5	0	2777	2777
SRL	389	56	445	338956	179546	518502
SWS	0	996	996	0	832189	832189
TAM	377	81	458	113620	56400	170020
UICOMM	0	3	3	0	3453	3453
UOSCR	0	42	42	0	38473	38473
URPLAN	7	0	7	485	0	485
VPH	0	4	4	0	496	496
VPP	0	49	49	0	4188	4188
VTED	0	28	28	0	53229	53229
WPGU	0	10	10	0	45379	45379
ZOOL	0	102	102	0	93028	93028
SUBTOTAL	27044	13196	40240	10059971	14817050	24877021
DCSSYS[3]	0	3380	3380	0	6048736	6048736
OVRHED[4]	0	2	2	0	0	0
REFUND[5]	0	113	113	0	286190	286190
UADP[6]	0	43	43	0	24992	24992
XDCS[7]	0	43	43	0	299666	299666
XMAINT[8]	0	39	39	0	221864	221864
XSSS[9]	0	288	288	0	91056	91056
TOTAL	27044	17104	44148	10059971	21789554	31849525

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TABLE III NOVEMBER 1969

UNITS CHARGED--360/75

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	790	69	859	122819	6001	128820
ACCY	1093	45	1138	25197	5918	31115
ADV	0	36	36	0	2802	2802
AGE	62	193	255	8782	46807	55589
AGEC	689	139	828	29662	39784	69446
AGRON	549	178	727	15126	16583	31709
ANS	0	81	81	0	14798	14798
ARCH	33	0	33	1354	0	1354
ARL	0	16	16	0	1782	1782
ASTR	13	113	126	389	18225	18614
BADM	63	26	89	10892	2144	13036
BECBSR	0	6	6	0	146	146
BINRES	0	14	14	0	2503	2503
BOT	0	4	4	0	282	282
CE	1897	1460	3357	175473	190818	366291
CERL	0	26	26	0	6181	6181
CEUSA	0	12	12	0	1388	1388
CHE	699	1415	2114	29659	378110	407769
CIRCE	0	14	14	0	2967	2967
CRC	0	21	21	0	472	472
CSL	0	72	72	0	17435	17435
DATLOG	0	15	15	0	1018	1018
DCS	13364	473	13837	420739	96860	517599
DS	32	99	131	159	21220	21379
DUE	0	30	30	0	6034	6034
ECON	64	85	149	3512	17441	20953
ED	3	150	153	185	29931	30116
EDADM	0	38	38	0	22195	22195
EDPSY	433	3	436	11301	118	11419
EE	2529	800	3329	71367	112315	183682
ENGADM	0	197	197	0	75293	75293
ENGCST	0	81	81	0	36675	36675
ENGH	395	0	395	10685	0	10685
ENGLSH	0	2	2	0	0	0
FIN	367	2	369	128935	476	129411
FT	0	49	49	0	4468	4468
GENE	165	9	174	3612	211	3823
GEOG	140	66	206	31359	5643	37002
GEOL	84	135	219	7160	23173	30333
GRDCOL	0	6	6	0	1076	1076
HEC	0	2	2	0	876	876
HORT	0	23	23	0	1733	1733
ICR	0	395	395	0	76667	76667
IE	5	0	5	110	0	110
IGPA	0	17	17	0	2284	2284
ILLCF	0	1	1	0	5	5
ILR	0	33	33	0	3078	3078
IREC	0	1	1	0	53	53
LIBS	0	9	9	0	1256	1256
MATH	137	36	173	5403	4364	9767
MATRL	0	620	620	0	190110	190110
MCBIO	0	2	2	0	103	103
ME	2010	531	2541	72138	82185	154323

MKTG	0	67	67	0	4835	4835
MMPE	0	7	7	0	273	273
MUSIC	38	124	162	10656	45821	56477
NHS	0	4	4	0	237	237
NUCE	27	156	183	4989	56550	61539
OAC	0	13	13	0	405	405
OAS	0	33	33	0	8482	8482
OIR	0	148	148	0	26243	26243
PEM	0	98	98	0	16993	16993
PHYB	0	80	80	0	17549	17549
PHYCS	46	1794	1840	1436	145922	147358
PHYSL	0	42	42	0	824	824
PHYX	0	301	301	0	180991	180991
POLS	50	45	95	7680	3522	11202
PROVST	0	8	8	0	1067	1067
PSYCH	238	741	979	61897	280351	342248
REC	15	2	17	1838	1638	3476
SCONS	0	4	4	0	3843	3843
SCS	0	5	5	0	13095	13095
SGS	0	212	212	0	28817	28817
SOC	238	44	282	11665	6036	17701
SOCW	3	33	36	127	6482	6609
SPCH	0	11	11	0	1102	1102
SPED	0	5	5	0	174	174
SRL	389	56	445	55777	23694	79471
SWS	0	996	996	0	145479	145479
TAM	377	81	458	49208	17274	66482
UICOMM	0	3	3	0	238	238
UOSCR	0	42	42	0	6646	6646
URPLAN	7	0	7	27	0	27
VPH	0	4	4	0	30	30
VPP	0	49	49	0	336	336
VTED	0	28	28	0	7554	7554
WPGU	0	10	10	0	3598	3598
ZOOL	0	102	102	0	7042	7042
SUBTOTAL	27044	13198	40242	1391318	2635150	4026468
UCSSYS[3]	0	3380	3380	0	741593	741593
UVRHED[4]	0	2	2	0	0	0
REFUND[5]	0	111	111	0	46031	46031
UADP[6]	0	43	43	0	2372	2372
XUCS[7]	0	43	43	0	13080	13080
XMAINT[8]	0	39	39	0	18231	18231
XSSS[9]	0	288	288	0	8485	8485
TOTAL	27044	17104	44148	1391318	3464942	4856260

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TABLE III NOVEMBER 1969

SECONDS--1800 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGE	0	4	4	0	6504	6504
CE	0	12	12	0	5838	5838
CRC	0	1	1	0	699	699
DCS	50	0	50	11979	0	11979
ECON	0	19	19	0	228	228
EE	0	32	32	0	10751	10751
MATRL	0	15	15	0	553	553
MUSIC	0	51	51	0	11096	11096
NUCE	0	6	6	0	1799	1799
PHYCS	0	3	3	0	2756	2756
PHYSL	0	1	1	0	786	786
PHYX	0	21	21	0	7472	7472
SUBTOTAL	50	165	215	11979	48482	60461
DCSSYS[3]	0	25	25	0	8468	8468
REFUND[4]	0	1	1	0	102	102
TOTAL	50	191	241	11979	57052	69031

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error

Table I - IBM 360/20

Summary of Use

November, 1969

Scheduled Engineering	6:29
Unscheduled Engineering	13:21
Maintenance	5:15
Production	236:03
Idle	204:52
Total Time	466:00

Table II - 360/20

Summary of Machine Errors

November, 1969

2203 Printer	5
2560 MFCM	1
Total	6

TABLE III NOVEMBER 1969

MINUTES--360/20 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	15	0	15	121	0	121
ACCY	19	29	48	141	795	936
ADV	0	2	2	0	11	11
AGE	4	36	40	19	239	258
AGEC	7	29	36	58	375	433
AGRON	17	14	31	32	122	154
ANS	3	14	17	11	86	97
ARL	C	4	4	0	8	8
ASTR	1	8	9	2	25	27
BADM	0	1	1	0	2	2
BINRES	C	3	3	0	4	4
CE	24	50	74	112	432	544
CERL	0	3	3	0	12	12
CHE	23	63	86	38	782	820
CSL	C	6	6	0	26	26
DATLOG	0	4	4	0	16	16
DCS	515	59	574	1641	554	2195
DS	C	8	8	0	64	64
ECON	1	12	13	13	58	71
ED	C	33	33	0	623	623
EDADM	0	7	7	0	85	85
EDPSY	37	0	37	93	0	93
EE	34	31	65	115	220	335
ENGADM	0	27	27	0	269	269
ENGCST	0	8	8	0	84	84
ENGH	9	0	9	11	0	11
FIN	5	0	5	9	0	9
FOR	0	1	1	0	4	4
FT	0	2	2	0	4	4
GENE	12	0	12	67	0	67
GEOG	12	4	16	73	32	105
GEOL	4	19	23	55	274	329
GER	0	1	1	0	17	17
HORT	0	4	4	0	38	38
ICR	0	37	37	0	461	461
IE	2	0	2	3	0	3
IGPA	C	2	2	0	12	12
ILR	C	7	7	0	27	27
MATH	5	3	8	30	7	37
MATRL	0	48	48	0	310	310
ME	49	36	85	188	262	450
MKTG	0	2	2	0	17	17
MMPE	0	1	1	0	2	2
MUSIC	1	12	13	3	151	154
NHS	0	2	2	0	3	3
NUCE	6	15	21	54	75	129
OAC	C	7	7	0	20	20
OIR	0	5	5	0	66	66
PEM	C	8	8	0	52	52
PERRIF	0	3	3	0	9	9
PEW	0	1	1	0	5	5
PHYB	C	6	6	0	12	12
PHYCS	C	68	68	0	314	314

HYSL	0	1	1	0	1	1
HYX	C	23	23	0	88	88
OLS	6	4	10	28	56	84
ROVST	0	3	3	0	35	35
SYCH	43	41	84	625	325	950
EC	6	0	6	69	0	69
GS	0	10	10	0	68	68
OC	72	15	87	242	159	401
OCN	0	1	1	0	67	67
RL	28	5	33	225	38	263
WS	0	3	3	0	17	17
AM	19	8	27	103	39	142
ICOMM	0	2	2	0	14	14
OSCR	0	11	11	0	73	73
TED	C	7	7	0	52	52
OCL	0	8	8	0	47	47
UBTOTAL	979	887	1866	4181	8145	12326
SSYS[3]	0	278	278	0	2061	2061
EFUND[4]	0	5	5	0	26	26
ADP[5]	C	7	7	0	24	24
OCS[6]	C	3	3	0	6	6
MAINT[7]	C	378	378	0	14911	14911
OTAL	979	1558	2537	4181	25173	29354

See list of departmental codes following
Training and Education
System Improvement and Modifications
Rerun of User Jobs Due to Machine or System Error
University Administrative Overhead Use
System Updating
System Maintenance

TABLE III NOVEMBER 1969

MINUTES--SERVICE PROGRAMMING

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGEC	C	2	2	0	210	210
CE	C	3	3	0	120	120
CRC	0	1	1	0	180	180
SUBTOTAL	0	6	6	0	510	510
TOTAL	0	6	6	0	510	510

1 See list of departmental codes following
2 Training and Education

TABLE III NOVEMBER 1969

CARDS KEYPUNCHED

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	1	0	1	200	0	200
ACCY	0	1	1	0	400	400
AGEC	0	3	3	0	2000	2000
ANS	2	4	6	1100	650	1750
ASTR	0	1	1	0	700	700
BADM	0	2	2	0	450	450
CHE	0	1	1	0	1800	1800
DCS	4	7	11	1000	1300	2300
DSFA	0	1	1	0	1300	1300
ECON	0	1	1	0	1800	1800
ED	0	6	6	0	1550	1550
EDPSY	0	1	1	0	1500	1500
EE	0	2	2	0	900	900
FT	0	4	4	0	1200	1200
GENE	1	0	1	150	0	150
GEOG	0	2	2	0	1100	1100
GEOL	3	3	6	2550	1600	4150
HORT	0	3	3	0	3400	3400
ILR	0	5	5	0	2000	2000
MATRL	0	3	3	0	4500	4500
ME	0	1	1	0	750	750
PEM	0	4	4	0	1200	1200
PHYCS	0	1	1	0	100	100
POLS	1	2	3	700	600	1300
PSYCH	0	3	3	0	2900	2900
REC	1	0	1	900	0	900
SOC	0	1	1	0	1200	1200
SRL	1	0	1	200	0	200
URPLAN	1	0	1	100	0	100
VTED	0	1	1	0	100	100
ZOOL	0	1	1	0	500	500
SUBTOTAL	15	64	79	6900	35500	42400
OCSSYS[3]	0	53	53	0	31400	31400
TOTAL	15	117	132	6900	66900	73800

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications

Table I - IBM 360/50-75

Summary of Use

December, 1969

Scheduled Engineering	07:00:00	
Unscheduled Engineering	10:41:00	
Air Conditioning	00:10:00	
Idle	08:00:00	
	Subtotal	25:51:00
Batch	670:58:00	
System Maintenance and Development	47:11:00	
	Total	744:00:00

Table II - IBM 360/50-75

Summary of Errors

December, 1969

Data Adaptor Unit - 2701		1
75 CPU		1
Cons. 1		1
	Total	3

TABLE III DECEMBER 1969

CENTISECONDS--360/75 PROCESSOR TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	605	170	775	2010181	65348	2075529
ACCY	906	14	920	354641	14282	368923
ADV	0	20	20	0	27266	27266
AGE	124	180	304	233276	852539	1085815
AGEC	164	250	414	220090	288965	509055
AGRON	672	185	857	290705	124262	414967
ANS	0	145	145	0	198496	198496
ANTH	4	0	4	12910	0	12910
ARCH	23	0	23	264126	0	264126
ARL	0	42	42	0	55433	55433
ASTR	34	123	157	65855	330904	396759
BADM	261	124	385	785141	341849	1126990
BECBSR	0	33	33	0	9832	9832
BINRES	0	1	1	0	7192	7192
BIOPH	60	2	62	57785	581	58366
BOT	0	64	64	0	43138	43138
CE	2595	1424	4019	2846341	4671600	7517941
CERL	0	2	2	0	468	468
CEUSA	0	31	31	0	42507	42507
CHE	567	1025	1592	356728	3614318	3971046
CIRCE	0	48	48	0	112307	112307
CRC	0	66	66	0	45917	45917
CSL	0	37	37	0	38499	38499
CATLOG	0	2	2	0	5028	5028
CCS	12479	422	12901	6199323	2289101	8488424
DS	11	149	160	430	453595	454025
ECON	45	57	102	326359	84195	410554
ED	61	148	209	65772	264624	330396
EDADM	0	58	58	0	66784	66784
EDPSY	517	9	526	184559	10059	194618
EE	1164	700	1864	1468490	2445826	3914316
ENGADM	0	149	149	0	164688	164688
ENGCST	0	106	106	0	453619	453619
ENGH	321	0	321	113835	0	113835
ENGLSH	0	28	28	0	5276	5276
FIN	140	9	149	775040	7720	782760
FT	0	26	26	0	40514	40514
GENE	170	11	181	46661	1930	48591
GEOG	90	-4	86	128675	-55570	73105
GEOL	152	229	381	201101	325556	526657
GER	0	31	31	0	105593	105593
HEC	0	4	4	0	2335	2335
HED	0	4	4	0	93282	93282
HONORS	0	13	13	0	28546	28546
HORT	0	17	17	0	12701	12701
ICR	0	402	402	0	438031	438031
IE	33	0	33	3750	0	3750
IGPA	0	25	25	0	34090	34090
ILLCE	0	1	1	0	22	22
ILR	0	34	34	0	10348	10348
LIBS	0	15	15	0	31499	31499
MATH	176	56	232	88825	73830	162655
MATRL	0	530	530	0	4153039	4153039

MCBIO	0	34	34	0	11770	11770
ME	1109	606	1715	568278	1502553	2070831
MKTG	0	29	29	0	49401	49401
MMPE	0	7	7	0	1041	1041
MUSIC	25	13	38	52888	22419	75307
NHS	0	17	17	0	60768	60768
NUCE	23	236	259	10889	214665	225554
OAS	0	33	33	0	43934	43934
OEESPC	0	3	3	0	1479	1479
OIR	0	228	228	0	258404	258404
PEM	0	70	70	0	39900	39900
PHYB	0	120	120	0	216809	216809
PHYCS	14	1301	1315	1714	3398932	3400646
PHYSL	0	87	87	0	14008	14008
PHYX	0	153	153	0	1245574	1245574
PLPA	20	0	20	308	0	308
POLS	65	29	94	55398	30203	85601
PROVST	0	28	28	0	25990	25990
PSYCH	280	595	875	255513	1949716	2205229
REC	87	13	100	233567	49333	282900
SCONS	0	29	29	0	48948	48948
SCS	0	29	29	0	69943	69943
SGS	0	148	148	0	183976	183976
SOC	162	52	214	55637	72226	127863
SOCW	2	0	2	77	0	77
SPCH	0	2	2	0	705	705
SRL	223	62	285	559140	293851	852991
SWS	0	706	706	0	622940	622940
TAM	168	52	220	351186	196390	547576
UICOMM	0	10	10	0	926	926
UOSCR	0	57	57	0	43863	43863
URPLAN	3	0	3	83	0	83
VPH	0	5	5	0	9690	9690
VPP	0	20	20	0	1683	1683
VTED	0	16	16	0	37330	37330
WPGU	0	3	3	0	15287	15287
ZOOL	0	85	85	0	54813	54813
SUBTOTAL	23555	12095	35650	19245277	33221434	52466711
DCSSYS[3]	0	2956	2956	0	5177476	5177476
REFUND[4]	0	138	138	0	393378	393378
UADP[5]	0	41	41	0	40282	40282
XDCS[6]	0	52	52	0	22993	22993
XMAINT[7]	0	54	54	0	297384	297384
XSSS[8]	0	81	81	0	22707	22707
TOTAL	23555	15417	38972	19245277	39175654	58420931

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 University Administrative Overhead Use
6 System Updating
7 System Maintenance
8 Special Short Shots

TABLE III DECEMBER 1969

INPUT/OUTPUT REQUESTS--360/75

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	605	170	775	269745	71371	341116
ACCY	906	14	920	307883	25445	333328
ADV	0	20	20	0	4217	4217
AGE	124	180	304	127825	539818	667643
AGEC	164	250	414	109356	366760	476116
AGRON	672	185	857	417488	117822	535310
ANS	0	145	145	0	120226	120226
ANTH	4	0	4	16164	0	16164
ARCH	23	0	23	54062	0	54062
ARL	0	43	43	0	46968	46968
ASTR	34	125	159	9576	106902	116478
BADM	262	124	386	146475	338563	485038
BECBSR	0	33	33	0	12507	12507
BINRES	0	1	1	0	2776	2776
BIOPH	60	2	62	56102	8403	64505
BOT	0	64	64	0	74559	74559
CE	2595	1426	4021	1954419	1392664	3347083
CERL	0	2	2	0	503	503
CEUSA	0	31	31	0	26715	26715
CHE	567	1025	1592	221071	1011898	1232969
CIRCE	0	48	48	0	98863	98863
CRC	0	66	66	0	67510	67510
CSL	0	37	37	0	28690	28690
DATLOG	0	2	2	0	2273	2273
DCS	12480	422	12902	6221880	672418	6894298
DS	11	149	160	198	195925	196123
ECON	45	57	102	328781	62695	391476
ED	61	148	209	59716	187755	247471
EDADM	0	58	58	0	59681	59681
EDPSY	517	9	526	208995	16480	225475
EE	1164	700	1864	569705	526813	1096518
ENGADM	0	149	149	0	211197	211197
ENGCST	0	106	106	0	270503	270503
ENGH	321	0	321	152234	0	152234
ENGLSH	0	28	28	0	7338	7338
FIN	140	9	149	275014	8631	283645
FT	0	26	26	0	32707	32707
GENE	170	11	181	69519	3336	72855
GEOG	89	-3	86	95161	-585	94576
GEOL	152	229	381	242846	293113	535959
GER	0	31	31	0	46647	46647
HEC	0	4	4	0	3724	3724
HED	0	4	4	0	94656	94656
HONORS	0	13	13	0	18831	18831
HORT	0	17	17	0	21230	21230
ICR	0	402	402	0	425308	425308
IE	33	0	33	8131	0	8131
IGPA	0	25	25	0	44149	44149
ILLCE	0	1	1	0	146	146
ILR	0	34	34	0	15235	15235
LIBS	0	15	15	0	44446	44446
MATH	176	56	232	87969	31213	119182
MATRL	0	530	530	0	507098	507098

MCBIC	0	34	34	0	16322	16322
ME	1109	606	1715	585528	380898	966426
MKTG	0	29	29	0	26481	26481
MMPE	0	7	7	0	2803	2803
MUSIC	25	13	38	20985	37571	58556
NHS	0	17	17	0	6203	6203
NUCE	23	236	259	15342	203886	219228
OAS	0	33	33	0	26422	26422
OEESPC	0	3	3	0	1384	1384
OIR	0	229	229	0	324224	324224
PEM	0	70	70	0	44764	44764
PHYB	0	120	120	0	143751	143751
PHYCS	14	1302	1316	2289	871537	873826
PHYSI	0	87	87	0	21727	21727
PHYX	0	154	154	0	733221	733221
PLPA	20	0	20	307	0	307
POLS	65	29	94	44158	44006	88164
PROVST	0	29	29	0	61906	61906
PSYCH	280	595	875	192913	1169507	1362420
REC	87	13	100	108433	21914	130347
SCONS	0	29	29	0	39580	39580
SCS	0	29	29	0	26992	26992
SGS	0	150	150	0	159266	159266
SOC	162	52	214	42002	62243	104245
SOCW	2	0	2	56	0	56
SPCH	0	2	2	0	795	795
SRL	223	62	285	576287	331790	908077
SWS	0	706	706	0	783171	783171
TAM	168	53	221	77825	30731	108556
UICOMM	0	10	10	0	3926	3926
UOSCR	0	57	57	0	73882	73882
URPLAN	3	0	3	171	0	171
VPH	0	5	5	0	13237	13237
VPP	0	20	20	0	6816	6816
VTED	0	16	16	0	14022	14022
WPGU	0	3	3	0	11283	11283
ZOOL	0	86	86	0	56096	56096
SUBTOTAL	23556	12109	33665	13676611	14018500	27695111
DCSSYS[3,4]	0	2956	2956	0	4545454	4545454
REFUND[4]	0	121	121	0	261381	261381
UADP[5]	0	41	41	0	36809	36809
XDCS[6]	0	52	52	0	180305	180305
XMAINT[7]	0	54	54	0	358655	358655
XSSS[8]	0	81	81	0	20402	20402
TOTAL	23556	15414	36970	13676611	19421506	33098117

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
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5 University Administrative Overhead Use
6 System Updating
7 System Maintenance
8 Special Short Shots

TABLE III DECEMBER 1969

UNITS CHARGED--360/75

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	605	170	775	120167	8030	128197
ACCY	906	14	920	33008	1610	34618
ADV	0	20	20	0	2592	2592
AGE	124	180	304	17710	80160	97870
AGEC	164	250	414	22620	37752	60372
AGRON	672	185	857	38945	14542	53487
ANS	0	145	145	0	21650	21650
ANTH	4	0	4	2400	0	2400
ARCH	23	0	23	16512	0	16512
ARL	0	43	43	0	4402	4402
ASTR	34	124	158	4578	28139	32717
BADM	262	124	386	57742	47473	105215
BECBSR	0	33	33	0	1222	1222
BINRES	0	1	1	0	823	823
BIOPH	60	2	62	4380	276	4656
BOT	0	64	64	0	5501	5501
CE	2595	1426	4021	281795	387477	669272
CERL	0	2	2	0	79	79
CEUSA	0	31	31	0	4359	4359
CHE	567	1025	1592	31396	242986	274382
CIRCE	0	48	48	0	15655	15655
CRC	0	66	66	0	8331	8331
CSL	0	37	37	0	3900	3900
DATLOG	0	2	2	0	296	296
DCS	12480	422	12902	626698	201874	828572
DS	11	149	160	47	47258	47305
ECON	45	57	102	51087	10774	61861
ED	61	148	209	6520	34305	40825
EDADM	0	58	58	0	6659	6659
EDPSY	517	9	526	26470	2188	28658
EE	1164	696	1860	101725	117449	219174
ENGADM	0	149	149	0	19460	19460
ENGCST	0	106	106	0	45784	45784
ENGH	321	0	321	11630	0	11630
ENGLSH	0	28	28	0	648	648
FIN	140	9	149	75563	819	76382
FT	0	26	26	0	4872	4872
GENE	170	11	181	4681	219	4900
GEOG	89	-3	86	15604	-3239	12365
GEOL	152	229	381	23460	37570	61030
GER	0	31	31	0	9046	9046
HEC	0	4	4	0	499	499
HED	0	4	4	0	15529	15529
HONORS	0	13	13	0	2915	2915
HORT	0	17	17	0	1975	1975
ICR	0	402	402	0	61324	61324
IE	33	0	33	471	0	471
IGPA	0	25	25	0	3172	3172
ILLCE	0	1	1	0	5	5
ILR	0	34	34	0	2026	2026
LIBS	0	15	15	0	6270	6270
MATH	176	56	232	9597	5374	14971
MATRL	0	530	530	0	245043	245043

MCBIO	0	34	34	0	1129	1129
ME	1109	606	1715	56529	101324	157853
MKTG	0	29	29	0	5932	5932
MMPE	0	7	7	0	212	212
MUSIC	25	13	38	2994	3145	6139
NHS	0	17	17	0	5525	5525
NUCE	23	235	258	1613	20964	22577
OAS	0	33	33	0	5800	5800
OEESPC	0	3	3	0	235	235
OIR	0	229	229	0	25061	25061
PEM	0	70	70	0	6957	6957
PHYB	0	120	120	0	23120	23120
PHYCS	14	1300	1314	290	220808	221098
PHYSL	0	87	87	0	1576	1576
PHYX	0	154	154	0	157591	157591
PLPA	20	0	20	11	0	11
POLS	65	29	94	7419	5263	12682
PROVST	0	28	28	0	7149	7149
PSYCH	280	595	875	33231	203271	236502
REC	87	13	100	18485	5884	24369
SCONS	0	29	29	0	6156	6156
SCS	0	29	29	0	7999	7999
SGS	0	150	150	0	20908	20908
SOC	162	52	214	7994	11089	19083
SOCW	2	0	2	10	0	10
SPCH	0	2	2	0	123	123
SRL	223	62	285	84543	39810	124353
SWS	0	706	706	0	71177	71177
TAM	168	53	221	32297	17835	50132
UICOMM	0	10	10	0	267	267
UOSCR	0	57	57	0	7047	7047
URPLAN	3	0	3	9	0	9
VPH	0	5	5	0	931	931
VPP	0	20	20	0	428	428
VTED	0	16	16	0	4236	4236
WPGU	0	3	3	0	1247	1247
ZOOL	0	86	86	0	4830	4830
SUBTOTAL	23556	12100	35656	1830231	2792102	4622333
DCSSYS[3]	0	2956	2956	0	565782	565782
REFUND[4]	0	128	128	0	38041	38041
UADP[5]	0	41	41	0	3940	3940
XDCS[6]	0	52	52	0	8266	8266
XMAINT[7]	0	54	54	0	39623	39623
XSSS[8]	0	81	81	0	1775	1775
TOTAL	23556	15412	38968	1830231	3449529	5279760

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 University Administrative Overhead Use
6 System Updating
7 System Maintenance
8 Special Short Shots

TABLE III DECEMBER 1969

SECONDS--1800 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGE	0	8	8	0	11973	11973
BIOPH	10	0	10	3215	0	3215
CE	0	11	11	0	9380	9380
CRC	0	1	1	0	406	406
CCS	8	0	8	5098	0	5098
EE	0	25	25	0	10107	10107
GEOL	0	1	1	0	313	313
MATRL	0	14	14	0	158	158
MCBIO	0	1	1	0	306	306
MUSIC	0	4	4	0	488	488
NUCE	0	24	24	0	22682	22682
PHYCS	0	-2	-2	0	-2210	-2210
PHYSL	0	3	3	0	912	912
VPP	0	4	4	0	2061	2061
SUBTOTAL	18	94	112	8313	56576	64889
DCSSYS[3]	0	14	14	0	2671	2671
REFUND[4]	0	12	12	0	6754	6754
TOTAL	18	120	138	8313	66001	74314

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error

Table I - IBM 360/20

Summary of Use

December, 1969

Scheduled Engineering	7:22
Unscheduled Engineering	16:44
Maintenance	5:47
Production	305:38
Air-Conditioning	1:43
Idle	150:20
Total Time	487:34

Table II - 360/20

Summary of Machine Errors

December, 1969

2203 Printer	1
2560 MFCM	4
Total	5

TABLE III DECEMBER 1969

MINUTES--360/20 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAF	30	4	34	172	45	217
ACCY	26	3	29	199	59	258
AGE	9	36	45	70	462	532
AGEC	4	38	42	31	288	319
AGRCN	23	28	51	90	209	299
ANS	0	37	37	0	329	329
ANTH	0	1	1	0	16	16
ARCH	1	0	1	3	0	3
ARL	0	4	4	0	11	11
ASTR	2	17	19	6	121	127
BADM	8	16	24	62	98	160
BECRSR	0	1	1	0	3	3
BOT	0	1	1	0	14	14
CE	65	52	117	321	442	763
CERL	0	1	1	0	42	42
CHE	20	63	83	60	647	707
CIRCF	0	3	3	0	99	99
CRC	0	5	5	0	51	51
CSL	0	8	8	0	172	172
DCS	642	52	694	1887	553	2440
DS	0	22	22	0	494	494
ECON	0	2	2	0	16	16
ED	3	16	19	26	126	152
EDPSY	50	0	50	299	0	299
EE	33	35	68	164	225	389
ENGADM	0	4	4	0	10	10
ENGCST	C	5	5	C	95	95
ENGH	5	0	5	13	0	13
ENGLSH	0	2	2	0	6	6
FIN	6	1	7	61	10	71
FOR	0	1	1	0	2	2
FT	0	2	2	0	3	3
GENE	13	0	13	58	0	58
GEOG	20	4	24	51	10	61
GEOL	24	28	52	329	292	621
GER	0	5	5	0	74	74
HED	0	1	1	0	2	2
HORT	0	2	2	0	6	6
ICR	0	36	36	0	548	548
IE	2	0	2	5	0	5
IGPA	0	5	5	0	21	21
ILR	C	1	1	0	1	1
LIBS	0	4	4	0	153	153
MATH	9	15	24	24	143	167
MATRL	C	59	59	0	431	431
ME	54	26	80	137	119	256
MKTG	0	3	3	0	21	21
MUSIC	0	5	5	0	21	21
NUCE	5	12	17	94	44	138
OAS	0	10	10	0	35	35
OFFSPC	0	1	1	0	1	1
OIR	0	8	8	0	159	159
PEM	0	5	5	0	145	145

PHYP	0	17	17	0	50	50
PHYCS	0	63	63	0	350	350
PHYSL	0	1	1	0	1	1
PHYX	0	18	18	0	97	97
POLS	11	7	18	22	134	156
PROVST	0	8	8	0	77	77
PSYCH	21	65	86	162	1012	1174
REC	5	3	8	22	34	56
SCS	0	2	2	0	3	3
SGS	0	12	12	0	140	140
SOC	9	9	18	163	111	274
SRL	11	12	23	162	466	628
SWS	0	3	3	0	24	24
TAM	9	10	19	26	80	106
UOSCR	0	9	9	0	87	87
USGS	0	2	2	0	21	21
VPH	0	7	7	0	95	95
VTED	0	6	6	0	17	17
ZOOL	0	15	15	0	54	54
SUBTOTAL	1120	959	2079	4719	9727	14446
DCSSYS[3]	0	333	333	0	3476	3476
REFUND[4]	0	7	7	0	48	48
LADP[5]	0	2	2	0	113	113
XDCS[6]	0	1	1	0	8	8
XMAINT[7]	0	295	295	0	10930	10930
TOTAL	1120	1597	2717	4719	24302	29021

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 University Administrative Overhead Use
6 System Updating
7 System Maintenance

TABLE III DECEMBER 1969

MINUTES--SERVICE PROGRAMMING

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGEC	0	2	2	0	300	300
CE	0	4	4	0	615	615
CIRCE	0	3	3	0	1005	1005
CRC	0	3	3	0	420	420
GEOG	0	1	1	0	150	150
GER	0	2	2	0	240	240
PROVST	0	1	1	0	670	670
SUBTOTAL	0	16	16	0	3400	3400
TOTAL	0	16	16	0	3400	3400

1 See list of departmental codes following
2 Training and Education

TABLE III DECEMBER 1969

CARDS KEYPUNCHED

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	1	1	2	200	300	500
AGE	0	5	5	0	6300	6300
AGEC	0	4	4	0	3100	3100
AGRON	1	0	1	50	0	50
ANS	0	1	1	0	200	200
ANTH	0	4	4	0	2100	2100
ASTR	0	4	4	0	11100	11100
BADM	0	2	2	0	800	800
CE	1	9	10	500	6700	7200
CHE	0	2	2	0	3500	3500
DCS	3	4	7	1450	650	2100
ED	0	5	5	0	700	700
EE	0	1	1	0	150	150
FIN	4	0	4	1000	0	1000
GEOG	1	1	2	1500	600	2100
GEOL	0	6	6	0	3100	3100
GER	0	1	1	0	500	500
HORT	0	2	2	0	2100	2100
ILR	0	1	1	0	200	200
MATRL	0	1	1	0	200	200
ME	0	2	2	0	450	450
MUSIC	0	2	2	0	800	800
NUCE	0	3	3	0	1600	1600
PHYCS	0	2	2	0	4300	4300
PHYX	0	18	18	0	28800	28800
POLS	2	0	2	300	0	300
PROVST	0	3	3	0	2200	2200
PSYCH	0	1	1	0	400	400
REC	1	0	1	100	0	100
SPED	0	1	1	0	500	500
VCM	0	1	1	0	1400	1400
ZOOL	0	2	2	0	4200	4200
SUBTOTAL	14	89	103	5100	86950	92050
DCSSYS[3]	0	48	48	0	17400	17400
REFUND[4]	0	2	2	0	900	900
TOTAL	14	139	153	5100	105250	110350

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error

TABLE III 4TH QTR 1969

CENTISECONDS--360/75 PROCESSOR TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	191C	356	2266	4628078	124249	4752327
ACCY	367C	82	3752	1072257	73960	1146217
ADV	C	68	68	0	78471	78471
AGE	519	672	1191	981007	1651430	2632437
AGEC	966	614	1580	424807	1245980	1670787
AGRCN	1984	499	2483	752463	457508	1209971
ANS	C	312	312	0	367999	367999
ANTH	4	0	4	12910	0	12910
ARCH	64	0	64	282573	0	282573
ARL	C	58	58	0	70262	70262
ASTR	47	362	409	70894	667185	738079
BADM	346	150	496	915182	351217	1266399
BECBSR	C	39	39	0	10728	10728
BINRES	C	71	71	0	166564	166564
BIOPH	60	10	70	57785	1397	59182
BOT	C	78	78	0	49226	49226
CE	5657	4212	9869	5881298	9438311	15319609
CERL	C	70	70	0	63863	63863
CEUSA	C	91	91	C	96602	96602
CHE	1752	3898	5650	1545676	15297141	16842817
CIRCE	C	74	74	0	154233	154233
CRC	C	129	129	0	173730	173730
CSL	C	190	190	0	306040	306040
DATLOG	C	20	20	0	16918	16918
DCS	41607	1479	43086	15754535	5205911	20960446
DS	43	411	454	1662	816265	817927
DUE	C	49	49	0	141316	141316
ECON	128	218	346	374916	232159	607075
ED	76	446	522	117447	760721	878168
EDADM	C	141	141	0	450847	450847
EDPSY	1615	36	1651	494066	18641	512707
EE	4434	2179	6613	2560466	5649138	8209604
ENGADM	C	520	520	0	1134368	1134368
ENGCST	C	269	269	0	1309012	1309012
ENGH	1250	0	1250	405890	0	405890
ENGLSH	C	30	30	0	5276	5276
FIN	618	54	672	2657016	268360	2925376
FOR	C	5	5	0	2507	2507
FT	C	143	143	0	117312	117312
GENE	701	21	722	221689	4167	225856
GEOG	328	167	495	564668	90710	655378
GEOL	258	472	730	270247	871770	1142017
GER	C	31	31	0	105593	105593
GRDCOL	C	6	6	0	11125	11125
HACDMH	C	2	2	0	28605	28605
HEC	C	19	19	0	14786	14786
HED	C	34	34	0	248720	248720
HONORS	C	13	13	0	28546	28546
HORT	C	77	77	0	61770	61770
ICR	C	1075	1075	0	1272311	1272311
IE	39	C	39	4946	0	4946
IGPA	C	42	42	0	57792	57792
ILLCF	C	9	9	0	847	847

ILR	C	180	180	0	134537	134537
IREC	C	13	13	0	8460	8460
LIBS	C	33	33	0	49163	49163
MATH	336	134	470	159237	217634	376871
MATRL	C	1784	1784	0	9906080	9906080
MCBIC	C	43	43	0	15648	15648
ME	4580	1376	5956	1543873	4239196	5783069
MKTG	C	130	130	0	113960	113960
MMPE	C	14	14	C	4445	4445
MUSIC	140	183	323	693253	537492	1230745
NHS	C	21	21	0	62652	62652
NUCE	78	682	760	53122	1400765	1453887
OAC	C	13	13	0	3374	3374
OAS	C	66	66	0	109349	109349
OFFSPC	C	3	3	0	1479	1479
OIR	C	737	737	0	1158522	1158522
ORME	C	6	6	0	634	634
PEM	C	228	228	0	213721	213721
PHYB	C	281	281	0	635262	635262
PHYCS	99	4201	4300	17278	6425203	6442481
PHYSL	C	164	164	0	39002	39002
PHYX	C	701	701	0	3852581	3852581
PLPA	20	0	20	308	0	308
POLS	144	158	302	139990	111061	251051
PRCVST	0	52	52	0	57728	57728
PSYCH	699	2056	2751	997624	7562152	8559776
REC	146	26	172	445183	90207	535390
SCONS	C	38	38	0	119772	119772
SCS	C	45	45	0	326992	326992
SGS	C	613	613	0	755057	755057
SOC	420	142	562	143555	298485	442040
SOCW	25	34	59	175843	42780	218623
SPAN	C	21	21	0	22167	22167
SPCH	C	18	18	0	13460	13460
SPED	C	33	33	0	10979	10979
SRL	665	192	857	920746	1002578	1923324
SWS	C	2504	2504	0	3565285	3565285
TAM	729	233	962	1356992	1585247	2942239
UICCMM	C	13	13	0	3364	3364
UOSCR	C	138	138	C	220935	220935
URPLAN	10	C	10	321	0	321
USGS	C	11	11	0	664	664
VPH	C	9	9	0	9978	9978
VPP	C	87	87	0	4626	4626
VTED	C	63	63	0	135556	135556
WPGU	C	15	15	0	58700	58700
ZOOL	C	278	278	0	1082163	1082163
SUBTOTAL	76163	37775	113938	46695803	95980684	142680487
DCSSYS[3]	0	9697	9697	0	19171975	19171975
OVRHED[4]	C	3	3	0	0	0
REFUND[5]	C	488	488	0	2259659	2259659
UADP[6]	0	146	146	0	675939	675939
XDCS[7]	C	189	189	0	104131	104131
XMAINT[8]	C	160	160	0	459036	459036

XSSS[9]	C	1291	1291	0	1867379	1867379
TOTAL	76163	49749	125912	466998031205188031672186O6		

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
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7 System Updating
8 System Maintenance
9 Special Short Shots

TABLE III 4TH QTR 1969

INPUT/OUTPUT REQUESTS--360/75

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	1872	356	2228	816609	174311	990920
ACCY	3637	81	3718	877234	143435	1020669
ADV	C	68	68	0	62694	62694
AGE	517	672	1189	577566	1159190	1736756
AGEC	966	612	1578	742476	1633098	2375574
AGRCN	1981	497	2478	957668	412739	1370407
ANS	C	309	309	0	255275	255275
ANTH	4	C	4	16164	0	16164
ARCH	64	0	64	67126	0	67126
ARL	C	59	59	0	64624	64624
ASTR	47	363	410	13358	313958	327316
BADM	347	150	497	217289	355259	572548
BECBSR	C	39	39	0	14229	14229
BINRES	C	71	71	0	131592	131592
BIOPH	60	10	70	56102	12650	68752
BOT	C	78	78	0	87422	87422
CE	5642	4169	9811	3916988	3979598	7896586
CERL	C	69	69	0	126265	126265
CEUSA	C	91	91	0	67158	67158
CHE	1748	3865	5613	653357	4113772	4767129
CIRCE	C	71	71	0	134144	134144
CRC	C	128	128	0	226536	226536
CSL	C	187	187	0	292370	292370
DATLOG	C	20	20	0	17327	17327
DCS	41581	1466	43047	12505596	2032645	14538241
DS	43	408	451	1069	413263	414332
DUE	C	49	49	0	37769	37769
ECON	126	218	344	365521	314492	680013
ED	76	439	515	81244	544030	625274
EDADM	C	136	136	0	383114	383114
EDPSY	1577	36	1613	362627	27607	390234
EE	4411	2172	6583	1626402	1950076	3576478
ENGADM	C	516	516	0	1666959	1666959
ENGCST	C	268	268	0	667426	667426
ENGH	1249	0	1249	503990	0	503990
ENGLSH	C	30	30	0	7338	7338
FIN	607	54	661	890928	294505	1185433
FOR	C	5	5	0	4948	4948
FT	C	141	141	0	115751	115751
GENE	699	21	720	261777	6799	268576
GEOG	327	167	494	274277	93219	367496
GEOL	256	471	727	348616	709917	1058533
GER	C	31	31	0	46647	46647
GRDCOL	C	6	6	0	15374	15374
HACDMH	C	2	2	0	39809	39809
HEC	C	19	19	0	22204	22204
HED	C	32	32	0	322063	322063
HONORS	C	13	13	0	18831	18831
HORT	C	77	77	0	87248	87248
ICR	C	1063	1063	0	1279979	1279979
IE	39	0	39	9709	0	9709
IGPA	C	42	42	0	76795	76795
ILLCF	C	6	6	0	2015	2015

ILR	C	180	180	0	168384	168384
IREC	C	13	13	0	9227	9227
LIBS	C	33	33	0	67408	67408
MATH	336	132	468	156804	75365	232169
MATRL	0	1781	1781	0	1666397	1666397
MCBIO	0	43	43	0	20893	20893
ME	4577	1377	5954	2055979	950842	3006821
MKTG	C	124	124	0	87424	87424
MMPE	C	14	14	0	4321	4321
MUSIC	139	183	322	187674	488105	675779
NHS	C	21	21	0	7208	7208
NUCE	78	674	752	79606	821665	901271
OAC	C	13	13	0	2784	2784
OAS	C	66	66	0	63830	63830
OFFSPC	C	3	3	0	1384	1384
OIR	C	737	737	0	1150071	1150071
ORME	C	6	6	0	382	382
PEM	C	228	228	0	200897	200897
PHYB	C	280	280	0	327657	327657
PHYCS	55	4181	4280	32500	2618798	2651298
PHYSL	C	161	161	0	41016	41016
PHYX	C	698	698	0	2341448	2341448
PLPA	20	C	20	307	0	307
POLS	144	158	302	128427	136106	264533
PROVST	C	53	53	0	121938	121938
PSYCH	688	2037	2725	602253	3499925	4102178
REC	146	26	172	490865	48705	539570
SCONS	C	38	38	0	74123	74123
SCS	C	43	43	0	61409	61409
SGS	C	613	613	0	633919	633919
SOC	420	141	561	106336	202270	308606
SOCW	25	33	58	220729	35882	256611
SPAN	C	21	21	0	50018	50018
SPCH	C	18	18	0	2170	2170
SPED	C	33	33	0	26981	26981
SRL	666	192	858	933996	846492	1780488
SWS	C	2492	2492	0	2308160	2308160
TAM	728	234	962	269759	183404	453163
UICOMM	C	13	13	0	7379	7379
UOSCR	C	137	137	0	266329	266329
URPLAN	10	0	10	656	0	656
USGS	C	11	11	0	1286	1286
VPH	C	9	9	0	13733	13733
VPP	C	86	86	0	12546	12546
VTED	C	63	63	0	79457	79457
WPGU	C	15	15	0	61728	61728
ZOOL	C	276	276	0	233410	233410
SUBTOTAL	75952	37543	113495	31409584	44981345	76390929
DCSSYS [3]	C	9612	9612	0	16364516	16364516
OVRHED [4]	C	3	3	0	0	0
REFUND [5]	C	452	452	0	848910	848910
UADP [6]	C	145	145	0	94902	94902
XDCS [7]	C	175	175	0	748276	748276
XMAINT [8]	C	159	159	0	939094	939094

XSSS[9]	C	1291	1291	C	715379	715379
TOTAL	75952	49380	125332	31409584	64692422	96102006

1 See list of departmental codes following
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TABLE III 4TH QTR 1969

UNITS CHARGED--360/75

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	1860	355	2215	293268	16626	309894
ACCY	3628	81	3709	98959	10563	109522
ADV	0	68	68	0	11385	11385
AGE	515	671	1186	73396	165306	238702
AGEC	966	610	1576	59244	150252	209496
AGRCN	1981	497	2478	86629	50134	136763
ANS	0	309	309	0	43799	43799
ANTH	4	0	4	2400	0	2400
ARCH	64	0	64	17974	0	17974
ARL	0	59	59	0	6184	6184
ASTR	47	363	410	4967	61238	66205
BADM	347	150	497	72756	49617	122373
BECBSR	0	39	39	0	1368	1368
BINRES	0	71	71	0	18303	18303
BICPH	60	10	70	4380	430	4810
BOT	0	78	78	0	6387	6387
CE	5633	4160	9793	559800	818666	1378466
CERL	0	69	69	0	14562	14562
CELSA	0	91	91	0	9554	9554
CHE	1746	3858	5604	126788	1025083	1151871
CIRCE	0	71	71	0	21434	21434
CRC	0	128	128	0	30489	30489
CSL	0	187	187	0	38438	38438
DATLOG	0	20	20	0	1384	1384
DCS	41556	1459	43015	1440284	453267	1893551
DS	43	408	451	206	86592	86798
DUE	0	49	49	0	9049	9049
ECON	126	218	344	55655	36951	92606
ED	76	437	513	12445	97552	109997
EDADM	0	135	135	0	46037	46037
EDPSY	1582	36	1618	54834	3807	58641
EE	4410	2157	6567	197216	339950	537166
ENGADM	0	515	515	0	153258	153258
ENGCST	0	268	268	0	114032	114032
ENGH	1249	0	1249	37990	0	37990
ENGLSH	0	30	30	0	648	648
FIN	607	54	661	238449	40301	278750
FOR	0	5	5	0	373	373
FT	0	141	141	0	14378	14378
GENE	695	21	716	20363	446	20809
GEOG	327	167	494	56240	12481	68721
GEOL	256	471	727	31978	85523	117501
GER	0	31	31	0	9046	9046
GRDCOL	0	6	6	0	1076	1076
HADMH	0	2	2	0	5652	5652
HEC	0	19	19	0	3047	3047
HEC	0	33	33	0	46758	46758
HONORS	0	13	13	0	2915	2915
HORT	0	77	77	0	8377	8377
ICR	0	1058	1058	0	168378	168378
IE	39	0	39	581	0	581
IGPA	0	42	42	0	5456	5456
ILLOF	0	6	6	0	105	105

ILR	0	180	180	0	22469	22469
IREC	0	13	13	0	1085	1085
LIBS	C	33	33	0	9619	9619
MATH	336	132	468	16253	17835	34088
MATRL	C	1773	1773	0	580C23	580C23
MCBIO	C	43	43	C	1468	1468
ME	4574	1378	5952	166793	270810	437603
MKTG	C	126	126	0	13398	13398
MMPE	C	14	14	0	485	485
MUSIC	139	182	321	40361	59964	100325
NHS	C	21	21	0	5762	5762
NUCE	7E	673	751	8125	136931	145056
OAC	C	13	13	0	405	405
OAS	C	66	66	0	14282	14282
OFFSPC	0	3	3	0	235	235
OIR	C	713	713	0	119579	119579
ORME	C	6	6	0	81	81
PEM	C	228	228	0	33274	33274
PHYB	C	279	279	0	55886	55886
PHYCS	99	4152	4251	2307	468896	471203
PHYSL	C	16C	16C	0	3329	3329
PHYX	C	698	698	0	463535	463535
PLPA	2C	C	20	11	0	11
POLS	144	156	300	19912	15841	35753
PRCVST	C	52	52	0	14722	14722
PSYCH	68E	2038	2726	116434	709788	826222
REC	146	26	172	64681	11471	76152
SCCNS	C	38	38	0	14375	14375
SCS	C	43	43	0	32079	32079
SGS	C	613	613	0	82391	82391
SOC	42C	141	561	20463	41313	61776
SOCW	25	33	58	32761	6482	39243
SPAN	C	20	2C	0	2928	2928
SPCH	C	18	18	0	1284	1284
SPED	C	33	33	0	1532	1532
SRL	666	192	858	142987	127818	270805
SWS	C	2487	2487	0	344C83	344083
TAM	728	233	961	101872	128540	230412
UICOMM	C	13	13	0	505	505
UOSCR	C	136	136	0	36114	36114
URPLAN	1C	C	10	36	0	36
USGS	C	1C	10	0	88	88
VPH	C	9	9	0	961	961
VPP	C	86	86	0	848	848
VTED	C	63	63	0	17654	17654
WPGU	C	15	15	0	5196	5196
ZOOL	C	276	276	0	69379	69379
SUBTOTAL	75890	37420	113310	4279798	8241400	12521198
OCSSYS [3,4]	C	958C	958C	0	2028686	2028686
OVRHED [5]	C	3	3	0	0	0
REFUND	C	461	461	0	184984	184984
UADP [6]	C	145	145	0	33806	33806
XDCS [7,8]	C	172	172	0	37822	37822
XMAINT	C	159	159	0	75971	75971

XSSS[9]	C	1286	1286	0	145512	145512
TOTAL	75890	49226	125116	4279798	10748181	15027979

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 System Use in Excess of User Estimated Usage
5 Rerun of User Jobs Due to Machine or System Error
6 University Administrative Overhead Use
7 System Updating
8 System Maintenance
9 Special Short Shots

TABLE III 4TH QTR 1969

SECONDS--1800 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGE	C	15	15	0	23029	23029
BIOPH	10	7	17	3215	446	3661
CE	C	23	23	0	15218	15218
CRC	C	2	2	0	1105	1105
DCS	58	0	58	17077	0	17077
ECON	C	22	22	0	258	258
EE	C	76	76	0	28061	28061
GEOL	C	1	1	0	313	313
MATRL	C	35	35	0	4457	4457
MCBIC	C	1	1	0	306	306
MUSIC	C	59	59	0	12303	12303
NUCE	C	35	35	0	26153	26153
PHYCS	C	1	1	0	546	546
PHYSL	C	4	4	0	1698	1698
PHYX	C	21	21	0	7472	7472
VPP	C	4	4	0	2061	2061
SUBTOTAL	68	306	374	20292	123426	143718
DCSSYS[3]	C	92	92	0	49193	49193
REFUND[4]	C	16	16	0	8956	8956
XDCS[5]	C	2	2	0	755	755
TOTAL	68	416	484	20292	182330	202622

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 System Updating

TABLE III 4TH QTR 1969

MINUTES--360/20 REAL TIME

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	63	13	76	379	64	443
ACCY	62	32	94	366	854	1220
ADV	C	4	4	0	39	39
AGE	24	113	137	267	1069	1336
AGEC	23	104	127	277	1031	1308
AGRCN	63	56	119	157	425	582
ANS	5	67	72	24	492	516
ANTH	C	1	1	0	16	16
ARCH	1	C	1	3	0	3
ARL	C	8	8	0	19	19
ASTR	3	45	48	8	247	255
BADM	8	18	26	62	102	164
BECBSR	C	1	1	0	3	3
BINRES	C	5	5	0	13	13
BOT	C	1	1	0	14	14
CE	97	135	232	489	1196	1685
CERL	C	7	7	0	96	96
CHE	59	207	266	161	2279	2440
CIRCE	C	9	9	0	211	211
CRC	C	12	12	0	148	148
CSL	C	23	23	0	312	312
DATLOG	C	4	4	0	16	16
DCS	1914	181	2095	4856	1567	6423
DS	C	44	44	0	608	608
ECON	1	28	29	13	121	134
ED	10	68	78	65	997	1062
EDADM	C	8	8	0	114	114
EDPSY	122	1	123	440	3	443
EE	77	108	185	295	803	1098
ENGADM	C	40	40	0	306	306
ENGCST	C	22	22	0	221	221
ENGH	18	0	18	29	0	29
ENGLSH	C	2	2	0	6	6
FIN	13	6	19	74	31	105
FOR	C	2	2	0	6	6
FT	C	6	6	0	12	12
GENE	35	0	35	151	0	151
GEOG	42	15	57	139	286	425
GEOL	30	66	96	399	811	1210
GER	C	6	6	0	91	91
HACDMH	C	1	1	0	29	29
HEC	C	2	2	0	51	51
HED	C	15	15	0	142	142
HORT	C	10	10	0	92	92
ICR	C	102	102	0	1221	1221
IE	4	0	4	8	0	8
IGPA	C	7	7	0	33	33
ILR	C	49	49	0	207	207
IREC	C	3	3	0	10	10
LIBS	C	4	4	0	153	153
MATH	14	27	41	54	186	240
MATRL	C	149	149	0	957	957
ME	164	107	271	483	615	1098

MKTG	C	12	12	0	48	48
MMPE	C	1	1	0	2	2
MUSIC	7	32	39	18	342	360
NHS	0	2	2	0	3	3
NUCE	12	58	70	161	291	452
OAC	C	7	7	0	20	20
OAS	C	10	10	0	35	35
OFFSPC	C	1	1	0	1	1
OIR	C	27	27	0	386	386
PEM	C	27	27	0	298	298
PERRIF	C	4	4	0	25	25
PEW	C	1	1	0	5	5
PHYB	C	31	31	0	78	78
PHYCS	0	176	176	0	881	881
PHYSL	C	2	2	0	2	2
PHYX	C	67	67	0	379	379
POLS	20	16	36	53	212	265
PROVST	C	28	28	0	297	297
PSYCH	72	198	270	801	2474	3275
REC	11	4	15	91	40	131
SCS	C	3	3	0	17	17
SGS	C	35	35	0	252	252
SOC	112	36	148	544	401	945
SOCW	C	1	1	0	67	67
SRL	53	19	72	547	529	1076
SWS	C	8	8	0	55	55
TAM	35	27	62	172	151	323
UICCMM	C	2	2	0	14	14
UOSCR	C	29	29	0	387	387
USGS	C	2	2	0	21	21
VPH	C	7	7	0	95	95
VTED	C	33	33	0	167	167
WPGU	C	4	4	0	25	25
ZOOL	C	29	29	0	124	124
SUBTOTAL	3174	2883	6057	11586	26449	38035
DCSSYS [3]	C	927	927	0	8048	8048
REFUND [4]	C	18	18	0	149	149
UADP [5]	C	18	18	0	169	169
XDCS [6]	C	12	12	0	67	67
XMAINT [7]	C	1244	1244	0	43397	43397
TOTAL	3174	5102	8276	11586	78279	89865

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 University Administrative Overhead Use
6 System Updating
7 System Maintenance

TABLE III 4TH QTR 1969

MINUTES--SERVICE PROGRAMMING

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AGEC	C	7	7	0	1530	1530
CE	C	9	9	C	1080	1080
CHE	C	1	1	0	1500	1500
CIRCE	C	3	3	0	1005	1005
CRC	C	5	5	0	900	900
FT	C	3	3	0	540	540
GEOG	C	4	4	0	705	705
GER	C	2	2	0	240	240
MATRL	C	2	2	0	420	420
PROVST	C	1	1	0	670	670
SUBTOTAL	0	37	37	0	8590	8590
TOTAL	C	37	37	0	8590	8590

1 See list of departmental codes following
2 Training and Education

TABLE III 4TH QTR 1969

CARDS KEYPUNCHED

DEPT[1]	NUMBER OF RUNS			NUMBER OF UNITS		
	CLASS[2]	RES	TOTAL	CLASS[2]	RES	TOTAL
AAE	2	1	3	400	300	700
ACCY	2	3	5	400	1700	2100
ADV	C	2	2	0	1700	1700
AGE	C	8	8	0	7600	7600
AGEC	0	11	11	0	6500	6500
AGRCN	1	C	1	50	0	50
ANS	4	8	12	1900	2150	4050
ANTH	C	4	4	0	2100	2100
ASTR	C	6	6	C	14700	14700
BADM	C	5	5	0	1850	1850
CE	1	9	10	500	6700	7200
CHE	C	5	5	0	6350	6350
CRC	C	49	49	0	8000	8000
DCS	17	21	38	4450	4850	9300
DSFA	C	1	1	0	1300	1300
ECCN	C	1	1	0	1800	1800
ED	C	14	14	0	2550	2550
EDPSY	2	3	5	200	1700	1900
EE	C	5	5	0	1850	1850
FIN	5	1	6	1200	100	1300
FT	C	9	9	0	2800	2800
GENE	1	0	1	150	0	150
GECG	1	5	6	1500	12600	14100
GEOL	4	9	13	2800	4700	7500
GER	0	1	1	0	500	500
HORT	C	6	6	0	5900	5900
ILR	C	6	6	0	2200	2200
MATRL	C	9	9	0	6350	6350
ME	C	3	3	0	1200	1200
MUSIC	C	2	2	0	800	800
NUCE	C	4	4	0	1700	1700
PEM	C	8	8	0	3500	3500
PEW	0	2	2	0	3500	3500
PHYCS	C	6	6	C	5200	5200
PHYX	C	29	29	C	48100	48100
POLS	3	5	8	1000	1700	2700
PRCVST	C	7	7	0	4250	4250
PSYCH	0	6	6	0	5200	5200
REC	2	1	3	1000	300	1300
SOC	C	1	1	0	1200	1200
SOCW	1	C	1	300	0	300
SPED	0	1	1	0	500	500
SRL	1	C	1	200	0	200
URPLAN	1	C	1	100	0	100
VCM	C	1	1	0	1400	1400
VTED	C	2	2	0	300	300
ZOOL	C	4	4	0	5200	5200
SUBTOTAL	48	284	332	16150	192900	209050

DCSSYS[3]	C	160	160	0	75900	75900
REFUND[4]	C	2	2	0	900	900
XDCS[5]	0	1	1	0	700	700
TOTAL	48	447	495	16150	270400	286550

1 See list of departmental codes following
2 Training and Education
3 System Improvement and Modifications
4 Rerun of User Jobs Due to Machine or System Error
5 System Updating

LIST OF DEPARTMENT CODES

The following list of codes are those codes for which the Department of Computer Science has on file one or more authorized signatures. If your department or office does not appear on this list, please write its full name in the department field on the Problem Specification Form even though it may require more than 6 characters.

AAE	Aero. and Astro. Eng.
ACCREC	Accounts Receivable
ACCY	Accountancy
ACTGDV	Accounting Division
ADV	Advertising
AFS	Air Force Science
AGE	Agricultural Eng.
AGEC	Agricultural Economics
AGED	Agricultural Ed.
AGREXT	Agricultural Extension
AGRON	Agronomy
ALUMNI	Alumni Assoc.
AMCDEC	Adolf Meyer Center Decatur Ill.
ANS	Animal Science
ANTH	Anthropology
ARCH	Architecture
ART	Art
ASTR	Astronomy
AUDIT	Auditing Division
AVI	Aviation
BADM	Business Admin.
BAND	Band
BCMPL	Bureau of Community Planning
BECBSR	Bureau of Econ. and Bus. Res.
BED	Business Ed.
BEDRES	Bureau of Ed. Res.
BINRES	Bureau of Institutional Res.
BIOPH	Biophysics
BOT	Botany
BURSAR	Bursar's Office
CE	Civil Eng.
CERE	Ceramic Eng.
CHE	Chemistry and Chemical Eng.
CICBIO	Comm. Inst. Coop. Bio. Grad. Prog.
CIRCE	Cen. for Instr. Res. and Curr. Ev.
CLASS	Classics
CMPTOL	Comptroller's Office
COMM	Communications
CP	City Planning
CPUBS	Champaign Public Schools
CRC	Children's Res. Center
CSL	Coordinated Science Lab.
CURLAB	Curriculum Lab.
CZR	Center for Zoonoses Res.
DANCE	Division of Dance
DCS	Dept. of Computer Science
DGS	Division of General Studies (LAS)
DNSTUD	Dean of Students
DNW	Dean of Women
DOW	Division of Waterways
DS	Dairy Science
DSFA	Dept. of Stud. Fin. Aid
DUE	Division of University Ext.
ECON	Economics
ED	College of Ed.
EDADM	Educational Admin. and Super.
EDPSY	Educational Psychology
EE	Electrical Eng.
ENGADM	Engineering Admin.
ENGCST	Engineering College and Station
ENGH	Engineering Honors Program
ENGLSH	English
ENTOM	Entomology
FIN	Finance
FOR	Forestry
FR	French
FT	Food Science
GENE	General Eng.
GEOG	Geography
GEOL	Geology
GER	Germanic Languages and Lit.
GRDCOL	Graduate College
GRK	Greek
GSA	Graduate Student Assoc.
HACDMH	Herman Adler Zone Center Champaign
HEC	Home Economics
HED	Health Ed.
HIST	History
HLTHSV	Health Services
HONORS	Honors Program
HORT	Horticulture
HOUDIV	Housing Division
HYG	Hygiene
ICR	Inst. of Communications Res.
IE	Industrial Eng.
IGPA	Inst. of Government and Public Affa
ILLCF	Illini Christian Fellowship
ILLDMH	State of Ill. Dept. of Mental Healt
ILR	Inst. of Labor and Industrial Rel.
INSTTV	Instructional TV
IREC	Inst. for Res. on Except. Children
ISEDAD	Ill. St. U. Dept. of Ed. Admin.
ITAL	Italian
JOURN	Journalism
LA	Landscape Architecture
LAS	Liberal Arts and Sciences
LAT	Latin
LAW	Law
LIBS	Library Science
LING	Linguistics
MATH	Mathematics
MATRL	Materials Res. Lab.
MCBIO	Microbiology
ME	Mechanical Eng.
MILS	Military Science
MKNLY	McKinley Hospital

MMPE	Min. Met. and Petr. Eng.
MUSIC	Music
NHS	Natural History Survey
NS	Naval Science
NUCE	Nuclear Eng.
OAC	Office of Agricultural Comm.
OAS	Office of Admin. Studies
OIR	Office of Instr. Resources
PEM	Phys. Ed. for Men and Grad PE
PERRIF	Pershing Rifles
PEW	Phys. Ed. for Women
PHIL	Philosophy
PHYB	Physics Betatron Lab.
PHYCS	Physics
PHYPLA	Physical Plant
PHYSL	Physiology
PHYX	Physics Project X
PLPA	Plant Pathology
POLS	Political Science
PORT	Portuguese
PROVST	Provost's Office
PSDEC	Spec. Ed. Decatur Public Schools
PSYCH	Psychology
PSYTR	Psychiatry
PUR	Purchasing Division
REC	Recreation
RHET	Rhetoric
RSOC	Rural Sociology
RTV	Radio and Television
RUSHIS	Russian and area Studies
SCONS	Soil Conservation Service
SCS	Student Counseling Service
SGS	State Geological Survey
SHCBRC	Small Homes Council
SLAV	Slavic Languages and Lit.
SOC	Sociology
SOCW	Social Work
SOLS	School of Life Sciences
SPAN	Spanish
SPCH	Speech and Theatre
SPED	Special Ed.
SRL	Survey Research Lab.
SWS	State Water Survey
TAM	Theoretical and Applied Mechanics
UADP	Univ. Admin. Data Processing
UCCTE	U-C Council on Teacher Ed.
UNIHI	Univ. High School
UOSCR	Univ. Off. of School and Coll. Rel.
URPLAN	Urban Planning
USGS	U. S. Geological Survey
VAH	Vet. Anatomy and Histology
VCM	Vet. Clinical Medicine
VMS	Vet. Medical Science
VPH	Vet. Path. and Hygiene
VPP	Vet. Phys. and Pharm.
VTED	Vocational Ed.
WPGU	WPGU Radio Station
ZOOL	Zoology

Chicago Circle

CCARCH	Architecture
CCCHE	Chemistry
CCDME	Materials Engineering
CCENEN	Energy Engineering
CCGEOL	Geology
CCPHCS	Physics
CCPSYC	Psychology
CCSCS	Stud. Counsel. Service
CCSOC	Sociology

Chicago Medical Center

MCCL	Med. Cen. Comp. Lab.
ORME	Off. of Res. in Med. Ed.
OT	Occupational Therapy

Ill. State University, Normal

ISEDAD	Dept. of Ed. Admin.

Western Ill., Macomb

WIULAB	West. Ill. Univ. Lab School

9.2 Research Problem Specifications

During the fourth quarter of 1969, 229 problem specifications were submitted to the Department for computation on the System/360. The following brief descriptions of these problems have been prepared for inclusion in this report by those submitting them. T indicates a calculation associated with a thesis.

3048 Physics. Quantum Mechanical Problems. Solution of quantum mechanical problems especially useful in optical properties of semiconducting materials. (A. Baldereschi)

3049 T Aeronautical and Astronautical Engineering. Gas Kinetics. The objective of this study is to solve the Collisionless Boltzmann equation with an external force term to represent the gas surface interaction. (C. Chrisman)

3050 Psychology. Attention In Infants. Studies on perception, attention and short term memory in human infants. (L. Cohen)

3051 Political Science. Nation-Builder. Exploration of relationship between selected social and economic variables relating to national development of 126 nations. (F. Coombs)

3052 Economics. Macroeconomic Simulation. The research project will study the merits of alternative strategies for macroeconomic planners by simulation of a macroeconomic model. (A. Duchan)

3054 T Psychology. Individual Differences in Perception. Factor analysis of perceptual judgments and uni-and multidimensional scalings of stimulus characteristics, correlations between factor projections and "outside" stylistic, intellectual, personalogical, and demographic variables, and consistency of and transitional generality of judgments will be investigated. (L. Ewert)

3055 T Chemistry and Chemical Engineering. Flame Stability. An investigation of the dynamic behavior of flames under hydrodynamic effects. (M. Fang)

3056 T Physics. Critical Properties of Models. Investigation of the critical properties of certain model systems through the use of both high and low temperature perturbation expansions. (M. Ferer)

3057 Agricultural Economics. The Impact of Industrialization on a Rural Social System (Hennepin Putnamn County, Illinois). To analyze the impacts of industrial development occasioned by the location of a large scale steel manufacturing complex on the family, economic, religious, and interest organizations and on attitudes and values of rural residents living within the immediate area where the industrial plant is located. (C. Folse)

3066 Sociology. Adult Education. Study of role conflicts among teachers and students in the University of Windsor, Ontario, Canada. (N. Mackinnon)

3068 Psychology. Hospitalized Schizophrenic Non-Schizophrenic. Investigation of differences between the evaluative judgments of hospitalized schizophrenic and non-schizophrenic patients. (H. Marcum)

3070 T Political Science. Criminal Justice. Interaction between police; prosecutors and judges; legal values and the administration of justice. (D. Neubauer)

3071 T Psychology. Social Stimuli Effects. The study investigating the effects of cooperating partner on the task performance satisfaction of schizophrenic patients and normal subjects. (T. Owen)

3072 T Physical Education for Men and Graduate P.E. Comparative Training Effects. The purpose of this study is to compare the training effects brought about by 1) Cureton's Low and Middle Gear Program and, 2) Cooper's Aerobics in young adult women in terms of Max VO_2, cardiac time components and selected hematological variables. (S. Plowman)

3073 Theoretical and Applied Mechanics. Fluid System Noise. Analysis of pressure wave production of noise in positive displacement pumps (fluid-power systems). (J. Robertson)

3076 T Nuclear Engineering. Perturbation Theory for LMFBR. Performance characteristics for liquid metal fast breeder reactors (LMFBR's) will be calculated by using both diffusion theory and transport theory. The range of applicability and accuracy will be investigated. (P. Rohan)

3077 T Chemistry and Chemical Engineering. Stability of a Tube Reactor. A study of the stability and control of a tubular reactor with recycle. (F. Stone)

3082 T Materials Research Laboratory. Mossbauer on MnCrSb Alloys. Use of $Mn_{1-x}Cr_xSb$ alloys as absorber for Sn decay. (P. Vernes)

3083 Electrical Engineering. Housekeeping Routines. Certain problems of a utilitarian nature arise from time to time which require access to the services and facilities of DCS. When making such requests a job number seems to be a prerequisite for further discussion. Therefore, this request is submitted in the interest of improved communications. (K. Vossler)

3084 Food Science. State of Milk Proteins. The ultimate of the study is to delineate the psysical state of the milk proteins as they exist in their natural environment. (R. Whitney)

3086 T Education, College of. Conservation of Number Problems. This research entails testing the Piagetian Paradigm dealing with the conservation of numbers. The number of subjects utilized were 120, ages 3, 4, 5, 6, and 7. (T. Yawkey)

3088 Division of University Extension. Review Special Programs. Evaluate the effectiveness of teacher workshops relative to student achievement. (R. Kreuger)

3089 Civil Engineering. Prestressed Concrete Reactor Vessels. General description is the same as number 1287. (B. Mohraz)

3091 Vocational and Technical Education. OEG 0-8-051319-3626. Item analyses and factor analyses of experiment forms of achievement tests in eight vocational areas. (T. Baldwin)

3093 Physical Education for Women and Graduate P.E. Perception-Motor Performance. Study will investigate the interrelations of physical, perceptual, perceptual-motor skills, academic achievement and personality variables in junior high school students. (M. Souder)

3098 T Psychology. Individual Differences Cue Utilization for Grade Point Averages in Graduates. Individual differences in cue utilization for predicting psychology graduate grade point averages. (E. Spitzer)

3099 T Herman Adler Zone Center Champaign. Data Evaluation Adler Staff. The purpose of this project is to determine how much time the extra-mural staff spends in each Adler program, what activities are performed in regards to the same and with whom these activities are performed. (N. Richards)

3100 Geography. Pattern Recognition. Project to use PAX-II as per Snively and Butt for nephanalysis of ATS-satelite pictures. (G. Stipanuk)

3101 Economics. Adaptive Behavior. Simulation Study of Stock Market as a Dynamic Process. (A. Pappas)

3104 Mathematics. Nonlinear Approximation. An algorithm has been developed for construction of certain types of nonlinear Chebychev approximations (including approximation with simultaneous interpolation) and it is proposed to test this algorithm on the computer. (G. Belford)

3106 Psychology. Attitude and Behavior. Analyses of data collected in social psychological studies dealing with the relationship between verbal attitudes and overt behavior. (I. Ajzen)

3107 Geography. SYMAP. To study the effect of various sample sizes and varying class intervals on the portrayal of spatially varying quantities. (F. Foster)

3108 Civil Engineering. Undergraduate Research Part. Mathematical optimization of a framed structure. (M. Chu)

3109 Sociology. Sociology of Education Manpower. A national survey of members of the American Sociological Association who are engaged in teaching and/or research related to sociology of education. (G. Summers)

3110 Sociology. High School Student Aspirations. Analysis of Illinois high school student educational and occupational aspirations. (G. Summers)

3111 T Aeronautical and Astronautical Engineering. Radiation Temperature Problem. The objective of this research is to find the temperature distribution in a radiating boundary layer. (H. Chen)

3113 T Educational Psychology. Religious Opinionaire. The formulation of a religious beliefs opinionnaire that will discriminate between those who hold a fundamentalist theological point of view and those who hold a liberal theological point of view. (P. Holland)

3114 T Nuclear Engineering. Turbulent Two-Stream Mixing. Digitizing of analog recorded data tracks followed by 360 data reduction and analysis. (B. Spencer)

3115 T Nuclear Engineering. Turbulent Transport in Tubes. Analog-to-Digital conversion of multichannel recorded data followed by 360 data reduction and analysis. (W. Burchill)

3116 T Psychology. Functions of Intense Stimuli. A study of the function of intense stimulation in reducing schizophrenic performance deficit. (R. Smith)

3119 T Educational Psychology. Affective Versus Cognitive Groups with Pre-College Blind Youths. A dissertation project comparing the relative effects of a 15-hours, week-end group experience between an affective sensitivity group, a cognitive discussion group, and a control group, each group having blind, pre-college adolescents. (D. Rutschmann)

3121 T Department of Computer Science. Boolean Algebra Minimization. This is an investigation of various Boolean algebra minimization techniques. Emphasis will be on algorithms which can solve problems involving more than eight variables and hundreds of minterms. (V. Tareski)

3123 T Political Science. Political Party Identification. Questionnaire analysis of social-psychological bases for political party identification within the youth group of the Peruvian Aprista Party. (E. Epstein)

3125 Agricultural Engineering. Soybean Harvest Analysis. Statistical analysis of soybean harvest data. (R. Nave)

3126 Psychology. Motivation and Personality Factors in Learning. The research is designed to assess the effects of individual differences in motivation and personality factors on school learning. (R. Cattell)

3127 T Electrical Engineering. Local Information Transfer. A further study of the influence of connectedness on system behavior, taking account not only of physical connections, but also, of actual information flow among connected parts. Also, a simulation of systems intended to display certain predicted behavior. (M. Gardner)

3133 T Economics. Price Index Construction. The project involves the calculation of a price index. Expenditure data will be fed in along with data on prices. The output will be an index for 1960-69 relevant to Illinois municipal input purchaes. (N. Malzer)

3136 Survey Research Laboratory. Study 038 Tabulations. Tabulations for public housing (Chicago) Survey. (R. Ferber)

3137 Survey Research Laboratory. Study 045 Tabulations. Tabulations for faculty benefits survey. (R. Ferber)

3138 Survey Research Laboratory. Study 038 Cleaning. Cleaning data for public housing (Chicago) Survey. (R. Ferber)

3139 T Agricultural Economics. Analysis Price Corn World Market. Discovery of the corn price mechanism in international markets and its impact on U.S. grain marketing by means of two approaches: (1) econometric models using the method of simultaneous equations, (2) spatial equilibrium models based on quadratic programming (QP-7). (T. Hieronymus)

3140 Center for Instructional Research and Curriculum Evaluation. Illinois Adult Learning Project. A three stage investigation of basic phenomena in adult learners, U.S.O.E. grant. (A. Groteluesche)

3143 Psychology. Tactile Memory VIII. Investigation of guessing biases in short term tactile memory as a function of interstimulus interval. (R. Bogartz)

3145 Physics. Moon Electron Universality. Investigation of high energy effects in electrodynamic systems. (J. Trefil)

3146 Animal Science. Energy Utilization. Diets or metabolites will be fed and/or infused to sheep at two levels of intake above maintenance.

The heat production at each level will be measured by indirect open-circuit calorimetry measuring O_2 consumption, CO_2, and CH_4. The total energy balance will be determined at each level intake. FØRTRAN AND SØUPAC programs will be used to calculate energy balance from the raw data and to regress heat production on energy intake. (D. Johnson)

3147 T Germanic Languages and Literatures. Concordance For German Text. 4000 lines of German poetry must be analyzed: 1) Alphabetical index of all words occurring in text. 2) A concordance of all words; 3) Alphabetical list of words classified by groups (noun, adjective ...) 4) List of capitalized words in text. 5) List of word clusters (e.g. several nouns strung together, etc.) 6) Printout of the text. (K. Hanson)

3148 Zoology. Oogenesis In Drosophila. A study of the effects of ovary size (ovariole number) on egg size and rate of egg production in the fruit fly, Drosophila melanogaster. (E. Brown)

3149 T Physical Education for Men and Graduate P.E. Factors Influencing Football Attendance. Ph.D thesis - The factors influencing football attendance at the University of Illinois, 1926-1968. I need to run 48 stepwise multiple regressions with 17 independent variables. I also need additional time on a standard regression program in order to test for serial correlation. Time estimate 20 minutes. (B. Bole)

3150 T Physical Education for Men and Graduate P.E. Blood Enzymes In Adult Men. Analysis of the results of a 16 week training program on blood serum components in adult males. (L. Donoho)

3152 Education, College of. Analysis of Teacher Creativity. Analysis of data concerning teachers' perceptions of their own and the creativity of their pupils; relating this information to scores from creativity tests from pupils and teachers and evaluations of materials designed to stimulate creative thinking. (S. Bahlke)

3153 X-Ray Structure Analysis. X-ray structure analysis of a number of compounds of organic or biological significance. (I. Paul)

3155 Advertising. Advertising Evaluation. This project involves the measurement of meaning elicited from specific advertisements. (D. Stewart)

3156 Department of Computer Science. Priority Quenes Analysis. Evaluation of priority assignments in multiserver systems having finite length queues. (E. Bowdon)

3158 Accountancy. UIF Touche Foundation, ARP. Analysis of questionnaires submitted to UIF Touche Foundation. (F. Neumann)

3159 T Education, College of. Close Procedure. A linguistic analysis of deaf and hearing children's language protocols using the technique of the close procedure. (W. Marshall)

3162 T Physical Education for Men and Graduate P.E. Active vs. Passive Recovery. Use an analysis of variance for determination of differences between active and passive recovery in certain situations. (P. Richter)

3163 Center for Instructional Research and Curriculum Evaluation. EPIE Research. The aim of this project is to develop a method for evaluating school texts through the use of objective type techniques. (T. Denny)

3164 Economics. Pricing of Legal Services. The effects fee schedules on pricing of legal fees and its consequence. (R. Arnould)

3165 Civil Engineering. Cavities in Rock. Reduction of data obtained from tests of lined model cavities in simulated rock. (J. Thibeaux)

3169 T Political Science. Roles of the Secretary of Defense. A frequency count and factor analysis of the roles of the Secretaries of Defense compilated from data of expert informants. (L. Carlson)

3174 T Mining, Metallurgy and Petroleum Engineering. River Meanders. Statistical analysis of data collected from river meanders and theoretically generated meanders, in order to establish a suitable stochastic model of river meanders. (A. Scheidegger)

3175 Office of Agricultural Communications. Pesticides Labeling Study. Two-year research grant from the United States Department of Agriculture to the University of Illinois, Office of Agricultural Communications, on pesticide labeling. (R. Salcedo)

3176 State Water Survey. Frequency Distribution for Rainfall Data. To determine the appropriate theoretical frequency distribution of point and area rainfall and the relation of these distributions to distance,

the correlation between points, and the time scale on which the event is measured. (P. Schickedant)

3177 Advertising. Media Allocation. Linear program solution to allocation of media dollars for packaged foodstuff, including scheduling of media vehicles. (D. Wetthaufer)

3178 Physics. Multiscattering Comparison. Investigation of high energy effects in nuclear systems. (J. Newmeyer)

3179 Materials Research Laboratory. Calculations of Bardeen-Tewordt Equations. Calculations of Bardeen-Tewordt equations. (W. Chen)

3180 Agricultural Economics. Dynamic Intergration Policy. Dynamic programming procedures will be used to develop optimal irrigation policy for corn. (E. Swanson)

3181 Materials Research Laboratory. Ionic Impurity. Description of Alkali Impurity in Potassium Hydroxide by Quantum Mechanics. (W. Flygare)

3182 T Agronomy. Thesis Data Analysis. Statistical analysis of Agronomic thesis research data. (S. Carmer)

3184 Electrical Engineering. Thermally-Pumped Lasers. Thermal pumping will be used to develop new lasers and to increase our understanding of lasers pumped by other means. (M. Fein)

3185 General Engineering. Examinations and Evaluations. Research in course examinations and in evaluation of instruction. (T. Hartley)

3186 T Psychology. Attitudes and Photo Releasing. The project entails the analysis of a variety of attitudinal and personality variables with respect to behavioral measures in a situation where subjects sign photographic releases. It also entails the analysis of a variety of linguistic and normative data and their relationship to the references considered important by the student. (R. Darroch)

3187 Psychology. IBM 1800 System Programs. Development of IBM 1800 System Programs. (E. Donchin)

3188 Business Administration. Management Control. Determination of optional rules used for controlling organizational activities. (H. Hinomoto)

3189 T Electrical Engineering. Sunrise. Study of D-Region ionization at sunrise. (Turco)

3190 T Anthropology. Residence of ADC Families. Analysis of the residence patterns of ADC families in Champaign County. (C. Stack)

3191 T Chemistry and Chemical Engineering. Inelastic Scattering Problems. Exact quantum mechanical calculations of inelastic scattering processes for atomic and molecular collisions. (B. Everling)

3192 T Chemistry and Chemical Engineering. Inelastic Molecular Scattering. Numerical solution of the quantum mechanical inelastic collision problem. (W. Eastes)

3193 T Chemistry and Chemical Engineering. Classical Inelastic Scattering. Numerical solution of differential equations which occur in the theory of the scattering of classical molecules. (M. Craigie)

3194 T Psychology. Political Preferences and SIM. Relationships among multidimensional similarity space, unidimensional preference space and the semantic space of political stimuli. (R. Shikiar)

3195 Survey Research Laboratory. Research Board/Development. Development of programs for Archive and Survey analysis. (R. Ferber)

3196 Zoology. Fluctuations in Populations. Analysis of animal populations in respect to changes in climate and differences in vegetation. (C. Kendeigh)

3198 T Aeronautical and Astronautical Engineering. Dynamics of Repeated Structures. An analytical study of dynamics of repeated structures is performed. (Vaichitis)

3199 T Chemistry and Chemical Engineering. Solid State Study. Solid state reactions and related crystal structure analyses. (D. McCullough)

3200 T Theoretical and Applied Mechanics. Viscoelastic Creep. Numerical approximations to creep compliance data will be made and then these approximations will be the integrands for numerical integration. (J. Ford)

3202 Industrial Engineering. Dendrite Morphology and Homogenization Behavior of Ternary Aluminum Alloys. Ternary aluminum alloys (the first contains 3 per cent magnesium and 8 per cent zinc) are cast under conditions of unidirectional heat flow. Sections from these castings are examined using metallographic and electron microbeam probe techniques to determine the dendrite morphology resulting from solidification. Other specimens are heat treated to partially homogenize the cast structure, then analyzed in a similar manner. (B. Bardes)

3204 T Materials Research Laboratory. Absorption in Gallium Arsenide. Study of effect of optically injected carriers on absorption of GaAs. (P. Dapkus)

3205 Physics. Raman Spectroscopy. Raman spectra of monovalent, substitutional impurities in alkali halides are being measured. Computer calculations based on lattice dynamical models will be made in order to explain the experimental observations. (M. Klein)

3206 Business Administration. Price/Quality Relationship. Exploring the relationship of price/quality as perceived by customers for a wide variety of products and brands. (D. Gardner)

3207 T Geography. Location of Power Plants. The dissertation is a locational analysis of power plants. (B. Smith)

3208 Natural History Survey. Mineral Content of Bird Feathers. The identification of goose nesting grounds by trace element analysis of wing feathers. (H. Hanson)

3210 Natural History Survey. Pheasant Physiology Studies. Investigating physiological parameters, mineral status, and pesticide levels in pheasants, taking into consideration sex, age, season, activity, and geographic region. (W. Anderson)

3211 Atmospheric Research Laboratory. The Time-Dependent Convection. The numerical study of time-dependent convection arising in a fluid which is heated at a constant rate. The two-dimensional non-linear equations are solved on the mesh points. (Y. Ogura)

3213 Business Administration. Analysis of Buyer Behavior. Multivariate analyses of two sets of large data collected based on Howard-Sheth theory of buyer behavior. These include measurements of attitude, behavioral intention and brand loyalty. (J. Sheth)

3214 Civil Engineering. Image Coordinate Refinement. The objective of this project is to determine the sensitivity of analytical aerotriangulation to image coordinate refinement parameters and develop an image coordinate refinement criterion which will indicate the level of refinement analysis necessary to meet specific requirements. (W. Marks)

3215 T Zoology. Geographic Variation Pseudoeurycea. A study of geographic variation in Plethodontial salamanders using an analysis of variation of regression lines and a chi square analysis. Merestic characters (morphological) will be compared using analysis of variance. Color pattern characters will be analyzed using Chi square analysis. (M. Landy)

3216 Institute of Government and Public Affairs. Municipal Price Index. This project is to develop expenditure weights and match them with appropriate price relatives to construct a price index. (G. Fisher)

3219 T Chemistry and Chemical Engineering. Molecular Scattering. To investigate the transfer of energy between vibrational and translational degrees of freedom for various interaction potentials. (G. Lasby)

3222 Electrical Engineering. Flourescent Lifetime. Use of the computer to solve transcendental equations relating fluorescent decay times to phase angles between excitation and emission. (J. Hammond)

3223 Economics. Consumers Choice and Stocks. This project considers the effects of stocks of consumer durable goods held by households on their purchases of new durables. The computer will be used in the analysis of data collected in a survey in Indianapolis, and in analysis of time series data. (W. McMahon)

3224 Business Administration. Economy Population and Economy Oligopoly. Two Parts. (1) Simulation of effects of population growth on

Indian Economy, using Coale-Hoover model. (2) Simulation of Oligopolistic Competitive Behavior. (J. Simon)

3226 T Civil Engineering. Structure-Medium Interaction. A study to evaluate the structure-medium interaction due to a plane elastic stress wave generated from dynamic disturbances. (E. Tabujara)

3227 Civil Engineering. Dispersion In Unsteady Flow. Same description used in specification form 1993. (E. Holley)

3228 Civil Engineering. Reinforced Concrete Arches. Same description used in specification form 1995. (G. Gurfinkel)

3229 Civil Engineering. Probability Aseismic Design. A comparison of the results obtained by deterministic and probabilistic procedures for earthquake problems will be made. (I. Gungor)

3230 Civil Engineering. Specially Varied Open Channel Flow. The purpose of the project is to numerically investigate the various terms in the complete one dimensional, steady dynamic equation for specially varied flow so that the implications of additional simplifications can be evaluated. (K. Chang)

3231 T Civil Engineering. Conventional Pile Driving. This is to replace specification form 1230. (J. Parola)

3232 Civil Engineering. Post Analysis of Shells. Same description used in specification form 1140. (P. Homan)

3233 Civil Engineering. Analysis of Structural Safety.
This is to replace specification form 1132. (M. Amin)

3234 Civil Engineering. Problem for Continuum Mechanics.
This is to replace specification form 1087. (L. Lopez)

3235 T Civil Engineering. Drag Forces on Bodies in N.N.F.
Aim is analytical determination of drag forces on bodies moving through Non-Newtonian Fluids. This is to be done via calculation of the energy dissipation by numerical methods. (H. Pazwash)

3236 Civil Engineering. Geometric Programming in Water Resources.
Investigation of use of geometric programming in water resources systems analysis. (E. Cetwinski)

3237 T Civil Engineering. Parameter Concrete Reactor Vessel.
Lumped-parameter analysis of prestressed concrete reactor vessel.
(R. Higashionna)

3238 T Civil Engineering. Rail Contact Stress Investigation.
This investigation involves the determination of rail stresses due to wheel-rail contact. (G. Martin)

3239 T Civil Engineering. Finite Element Analysis Bridge.
A finite element approach to the dynamic analysis of skewed continuous highway bridges. (A. Eberhardt)

3240 T Civil Engineering. Isoparametric Finite Element. Development of two and three dimensional isoparametric finite-element. (A. Gupta)

3241 Civil Engineering. Mechanics of Watershed Flow. Investigation on the uniqueness and linearity of the Unit Hydrograph. (B. Anderson)

3242 T Civil Engineering. Rainfall Effect on Sheet Flow. The effect of rainfall on spatially varied sheet flow is being studied. Turbulence and mean velocities are measured as well as the boundary shear. (Y. Yoon)

3243 Civil Engineering. Flow In Alluvial Rivers. Numerical analysis and data processing of resistance to flow in alluvial rivers. (Y. Liou)

3244 Civil Engineering. Wave Pressures. This research project is an investigation of the pressure distributions on vertically oriented circular cylinders under the action of breaking water waves. System 360 will be used to process data from experiemnts and to numerically regenerate pressure distributions using an analytical model. (R. Weggel)

3245 T Civil Engineering. Pavement Optimization. A study directed toward the establishment of principles and guidelines that can be used to promote the most effective use of local and stabilized materials in the construction of low traffic highway pavements. (Q. Robnett)

3246 T Civil Engineering. Three-Dimensional Finite Element. Development of a three-dimensional finite element program. This program

will be used to study the behavior of prestressed concrete reactor vessels with openings in the slab. (B. Karlesson)

3247 Civil Engineering. Reliability In Foundation. To propose models that will describe the uncertainties in soil strengths and compressibility, and to evaluate reliability of existing design criteria. (W. Tang)

3248 T Civil Engineering. Seismic Analysis of Piping. Seismic analysis of structure piping systems. (R. Kassawara)

3249 T Civil Engineering. Consolidation and Stress. Finite element technique for stress distribution analysis of and consolidation of a soil system. (F. Gau)

3250 T Civil Engineering. Irregular Slab Analysis. This project is being made to study the behavior of slabs with "spatter" columns. The computer is being used to obtain the necessary data. (C. Hofmayer)

3251 T Civil Engineering. Optimal Sample Intervals for WQ MON. The problem will involve the analysis of a long series of water quality data to describe trends, oscillations, and random variations followed by reanalysis of successively smaller samples of the data to determine how frequently measurements would be needed in order to satisfy particular purposes. (W. Betchart)

3252 T Civil Engineering. Finite Difference Models. Lumped-parameter and finite-element models for static stress analysis problems and dynamic wave propagation problems in solid media will be investigated. (Y. Uckan)

3253 Civil Engineering. Rainfall-Runoff Relationship. Mathematical simulation of rainfall-runoff relationship. (A. Benzvi)

3254 T Civil Engineering. Systems Analysis of Township Highways. A systems analysis of local rural road administrative units in Illinois. Research includes an extensive statistical analysis as input to a subsequent system evaluation. (W. Berg)

3255 Civil Engineering. Stability Problems in Hydrology. Study of stability problems in hydrologic systems. (S. Kareliotis)

3256 T Civil Engineering. Irrigation System Analysis. Analysis of irrigation systems. (J. Windsor)

3257 T Civil Engineering. Sludge Thickening. The computer will be used to assist analysis of experimental batch and continuous flow settling tests. (R. Dick)

3258 Civil Engineering. Dynamic Analysis. Dynamic influence of degrading stiffness on response of multistory buildings. (N. Nielsen)

3259 Civil Engineering. Proportion Modification Process. Study of convergence in sequential application of non-linear programming search,

and dynamic programming procedures to structural design processes.(R. Wright)

3260 T Civil Engineering. Structural Dynamics. Re-evaluation and extension of the procedures for dynamic analysis of structures with emphasis on earthquakes. (G. Estrada)

3261 T Civil Engineering. Operationa Research In Water Research. This study is concerned with the application of dynamic programming to the evaluation of the operation efficiency of surface and ground water storage systems. The conjunctive operation of these systems will be simulated for the optimum economic benefits. (M. Heidari)

3262 Civil Engineering. Games. Developing a construction management game for the construction environment. (D. Halpin)

3263 Civil Engineering. Stereometric Camera Systems. Stereometric camera systems in engineering applications. (R. Malhotra)

3265 T Speech and Theatre. Stage Fright. This is a factor analytic study of the dimensions of anticipated communicative anxiety. Through oblique and orthogonal rotation procedures, the variables related anxiety in communicative situations will be established. (W. Page)

3268 Animal Science. Genetics of Lamb K40 Content. Variability, heritability, and rate of selective progress, in the potassium - 40 content of lambs is being studied as a means of identifying animals of superior leanness. (H. Norton)

3269 Department of Computer Science. NonLnear Integral Equations. Investigation of practical methods of solving NonLinear Fredholm equations. (J. Davis)

3270 Geography. SMSA (Standard Metropolitan Statistical Areas) Gravity Model. An attempt to measure and predict through regression analysis and associated techniques, the existant relationships between population densities and the movement of goods among and between the SMSA's in the United States. (H. Roepke)

3271 Sociology. Changes in Indian Family Life. The research concerns a study of changes in the family life of gold miners of South India. The changes are measured by setting up the indicators related to tradition and modernity. (G. Ramu)

3272 Economics. Projections of Regional Growth. A test of the forecasting accuracy of several techniques for projecting regional economic growth. (H. Nourse)

3273 T Library Science. Doctoral Research on library problems. (G. Gritzmacher)

3274 T Department of Computer Science. Optimum and/or Networks. Optimal logic networks consisting of and/or gates will be synthesized by using integer programming. The synthesis will be done for double rail logic. Optimal networks will be obtained for all switching functions of these variables. (J. Culliney)

3275 T Department of Computer Science. Design of One-Bit Adders. Optimum logic networks for one-bit adders will be synthesized using integer programming. The networks will consist of various combinations of gates such as NOR and AND or NOR and NAND. (L. Shiau)

3276 T Chemistry and Chemical Engineering. Stability in Reaction Systems. Studying the behavior of chemical reactors. (M. Chang)

3277 T Electrical Engineering. LP (Log-Periodic) Antenna Transient Response. This research will determine the response of an LP antenna to a very short pulse of energy with the analysis being done in the time domain. (G. Perrine)

3278 T Physiology. Temperature Stress on Man. Ambient temperature as it affects working man will be monitored by changes in blood intermediate metabolities, oxygen consumption, metabolic mixture and total energy cost. (J. Serbin)

3279 Astronomy. Theory of Gaseous Nebulae. Computations of the thermal and ionization structure of gaseous nebulae will be made. A goal of this work is to determine whether or not a model for the Orion Nebula can be constructed which satisfactorily agrees with radio and optical observations. (R. Rubin)

3280 T Department of Computer Science. Logic Design with Nor-Or Gates. Optimal logic networks consisting of OR, NOR and NOR-OR gates will be synethesized by using integer programming. The synthesis will be done for both single and double rail logic. Optimal networks will be obtained for all

switching functions of three variables. (S. Chandersekaran)

3281 T Department of Computer Science. Separable Boolean Functions. The set of Boolean functions can be classified by three different separability criteria. Thus enumeration of properties of a separable, pseudo-separable, and marginally separable switching functions will be conducted. (C. Baugh)

3282 Electrical Engineering. Current Distribution Plasma. The current distribution on a linear antenna in a magnetoplasma is computed by solving the resulting integral equation by the method of moments. (P. Klock)

3283 Zoology. Numerical Phyletics. Improvement of procedures used for numerical taxonomy. Debugging of a computer program for deriving a phylogram based on parsimony of evolutionary change, and testing of a variety of clustering procedures for their optimality in replacing correct clusters. (D. Eades)

3284 Accountancy. Perceived Need Project. Computer time is needed to analyze data from questionnaires used to measure perceived need satisfactions from various positions within differing types of public accounting firms. (J. Deskins)

3285 Astronomy. Objective Prism Spectra. Digitized microphotometric data will be processed in the computer to yield stellar temperatures and luminosities. (K. Yoss)

3287 Recreation. Recreation and Economics. This study will investigate the ability of recreation participation rates to explain variation in individual explenditures for recreation. (A. Caskey)

3288 Electrical Engineering. D-Region Seasonal Variation. Interpretation of the seasonal variation of D-region electron densities in terms of the dynamics of the neutral upper atmosphere. (P. Ratnasiri)

3289 Chemistry and Chemical Engineering. X-Ray Structure Analysis. X-ray structure analysis of a number of compounds of organic or biological significance. (I. Paul)

3290 T Business Administration. Analysis of Channels of Distribution. The purpose of the research is to find out how changes that take place in an economy over time bring about changes in the marketing structure (channels of distribution). (I. Abdel-Galil)

3292 T Home Economics. Effects of MSG, Ribbtide-Beef. 1 x 12 factorial with three replications using a weight factor of 12 for factor A (control); further analysis on factor B using a 3 x 4 factorial. (M. Kruger)

3293 English. Writing Lab Evaluation. The project will result in a partial evaluation of the Writing Laboratory, Rhetoric 103. (H. Slotnick)

3294 Civil Engineering. Photon Transport Fundamentals. Data files in the form of punched cards will be prepared containing macroscopic gamma-ray interaction coefficients for the energy range 10 Kev to 50 Mev. In addition, some miscellaneous gamma-ray transport problems will be solved

using the method of moments and/or Monte Carlo procedures. (A. Chilton)

3295 T Agricultural Economics. Planning Optimum Farm Organization. Determining optimum production, marketing and financing alternatives in Colombia with the use of linear programming. (G. Rojas)

3298 Civil Engineering. Concrete Pressure Vessels. Analysis of data from the tests of prestressed concrete reactor containment vessels. (S. Paul)

3299 Civil Engineering. Television Mapping System. Determination of the internal geometry of a closed-circuit television system including equivalent focal length, position of the principal point and the geometric distortion characteristics. (K. Wong)

3300 Psychology. Impression Formation. Examines the effects on impression formation of the order in which people reveal their agreeing (or disagreeing) views to one another. (I. Steiner)

3302 Institute of Labor and Industrial Relations. Public Sector Labor Relations. An effort to determine significant factors which explain the scope of bargaining in the public sector. (P. Gerhart)

3303 Institute of Labor and Industrial Relations. Criterion Dimensionality. Factor analysis of performance variables collected at five points in time on a sample of 184 workers. (C. Hulin)

3304 Materials Research Laboratory. Magnetic Properties of Cerium Magnesium Nitrate. Study the effect of a magnetic impurity on the thermal conductivity and spin-lattice relaxation time in cerium magnesium nitrate. (A. Anderson)

3305 Civil Engineering. Non-Metric Photography. The problem deals with the evaluation of the photogrammetric potentials of non-metric cameras. (H. Karara)

3306 Civil Engineering. Rural Intersection Illum. Development of criteria for illumination requirements at rural highway intersections. (M. Lipinski)

3307 Agricultural Engineering. Water Balance Study. To plan irrigation systems using a water balance model. (W. Lembke)

3310 Agricultural Economics. Significant Other Project. An investigation of the type and extent of influence of significant others on the educational and occupational attainment process. (J. Woelfel)

3311 Survey Research Laboratory. Tabulations On 702. Analysis of Project 702 (NORC BILLING). (S. Sudman)

3313 T Psychology. Stress VS. Reinforcement. 2 x 2 design - stress vs. no stress; contingent vs. random punishment; investigate relative effects of stress vs. reinforcement on disfluencies; 4 measures of stress to validate stress manipulation procedures (pulse rate, behavioral checklist, self-report, amount of movement in chair as recorded by special cushion). (L. Crabb)

3316 T Nuclear Engineering. Lasers-II Optical Spectra. Models predicting the optical spectra excited by nuclear radiation will be tested and compared to experimental observations. Models for the slowing down spectra and excitation of high energy heavy ions will be developed and tested for use in the balance of excited states in plasmas produced by nuclear radiation. (T. Thiess)

3317 T Theoretical and Applied Mechanics. Mean Stress. Effect of mean stress on fatigue of aircraft metals. (N. Dowling)

3320 Civil Engineering. Plastic Analysis Shells. Develop and apply various lumped parameter and finite element methods to determine the plastic behavior of shell structures constructed from orthotropic materials. (W. Schnobrich)

3321 T Graduate College. AAAS-Formation. A statistical analysis and frequency correlation of characteristics of the members of the AAAS, 1848-1860, to determine and distinguish leadership characteristics of scientists during the formative years of the national American scientific "community".

3322 Material Research Laboratory. Signal Analysis. This project concerns autocorrelation analysis and power spectral density measurements of analytical signals. (J. Eakin)

3323 Office of Space Programming. OSP Calculations. This project tests the feasibility of using the 360 computer to do simple calculations on matrices of data of the type and size common in the Office of Space Programming. (J. Andrews)

3324 T Nuclear Engineering. Concrete Buildup Factors. Exposure and energy transmission buildup factors will be calculated for gamma rays penetrating concrete slab shields of various thicknesses. Several types of sources and concrete compositions will be considered. (T. Carlson)

3325 Special Education. Dissemination Research. Analysis of data received from agencies associated with the Dissemination Project to formulate basic information on effective dissemination. (W. Simmons)

3326 Survey Research Laboratory. Tabulations For Survey 049. Tabulations of C-U Black Housing Survey. (R. Ferber)

3327 Survey Research Laboratory. Cleaning For Survey 049. Cleaning of C-U Black Housing Survey. (R. Ferber)

3328 Animal Science. Atherosclerosis and Body Composition. To study the genetic and nutritional factors associated with the variation among swine in the extent of atherosclerosis and in the mature body composition. (T. Lohman)

3329 Electrical Engineering. Plasma Feedback. Study effect of feedback control on plasma instabilities. (J. Crowley)

3330 Physiology. Potassium Exchange in Heart. Extraction ratios and mean transit times for potassium and other metabolites will be computed from measurements of venous radioactivity following intra-arterial injections of multiple tracers. (F. Downey)

3331 Electrical Engineering. Interface and Bulk Phenomena Electronic properties of the insulator-semiconductor interface in the bulk in semiconductor materials are investigated under this contract grant which includes detailed studies of the orientation effect of the semiconductor substrate on the interface state concentration and energy level, the fixed oxide charge density, the interface of low frequency noise and surface scattering of electrons and holes. These problems require a considerable amount of numerical calculation for both the theoretical analysis and for the experimental measurements. The methods involved in the mathematical calculations include simple algebraic operations, numerical integrations of closed integrals and solutions of differential and integral equations. The input data are obtained either from theoretical considerations of the problem on hand or from the experimental measurements obtained in the laboratory. The theoretical computer results will be used to guide experiments and the calculated experimental data from the computor results will be compared with the theoretical calculation. (C. Sah)

3332 T Chemistry and Chemical Engineering. Rotating Convection. A study is being made of heat transfer in rotating fluids. (J. Hudson)

3333 T Sociology. Preschool Education. Comparison of school achievement of children who attended different types of preschools. (F. Handler)

3335 Sociology. Race In Cartegena. A study of race relations in Colombia, South America. (Solaun)

3336 T Agricultural Economics. A Model for Bank Asset-Liability Management. A linear programming model will be developed with which asset and liability management of rural banks can be evaluated. Special emphasis will be on acquisition of funds from the Farm Credit System to meet farm loan requests. (J. Hopkin)

3337 T Political Science. Labor Union Voting Behavior. Secondary analysis of the SRC election studies of 1952, 1956, 1960, and 1964. (J. Ra)

3338 Sociology. Changes in Indian Marriage Pattern. The problem concerns the changing patterns of marriage in India. The data to be analyzed are the advertisements in two major English newspapers seeking partners. (P. Wiebe)

3339 T Economics. Corporate Demand for Cash. To estimate a number of questions (using multiple regression analysis) relating corporate demand for cash to other current account variables. (J. Thomson)

3340 T Finance. Life Insurance. An analysis of product development in the life insurance industry. The analysis will be conducted using analysis of variance, correlation and other programs in the SOUPAC set of programs. (M. Dorfman)

3341 Psychology. Verbal Response Latency Oscillation. Response latency oscillation of learning letter-number pairs as an evaluation of past research involving incremental vs. all-or-none learning. (S. Platt)

3342 Psychology. Project Power Study One. A laboratory study of the effects of participation and decision issues on power distributions and attitudes in decision-making groups. (M. Wood)

3334 Institute of Labor and Industrial Relations. Market Structure and Profit Rates. Analysis between market structure and profit rates: a comparative study between Japan and the United States (Verusa)

3345 State Water Survey. Weather Modification on Agriculture. The research involves the evaluation of the potential benefits of weather modification on Agriculture. Emphasis will be placed upon the two major Illinois crops, corn and soybeans. Both the frequency distribution of climatic factors and agricultural technology and economic factors will be applied in deriving the solution of the problem. Techniques will be developed for extending the analyses to other crops and other regions of the Midwest and United States. (F. Huff)

3346 State Water Survey. Northeast Illinois System Analysis. The area of study includes the six county area that is commonly referred to as northeastern Illinois with the addition of Kendall County which is directly south of the industrial area south of Aurora in southern Kane County. The first generation model will be based on physical availability of groundwater versus demand. In the areas where there is not sufficient groundwater to meet projected demands, the model will show the need for Lake Michigan water. (A. Moench)

3348 Institute of Labor and Industrial Relations. Micro Wage Determination. An attempt to explore the determinants of wage changes at the enterprise level. (J. Scoville)

3349 Civil Engineering. Mailing List. Mailing list for Civil Engineering department use. (E. Danner)

3351 Survey Research Laboratory. Parking Study Tabulations. Tabulations of parking study conducted at the University of Illinois. (R. Ferber)

3353 T Home Economics. Effects Determining Changes on Consumption. Expenditures. Multivariate linear regression analysis using 13 independent variables to determine effects of these variables on consumption expenditures. (J. Hafstrom)

3354 State Water Survey. Analysis of Mixed Distributions. This research is oriented toward devising an operational methodology decomposing mixed distributions in hydrology (and other disciplines) into component normal distributions, finding their relative weights, means and variances and synthesizing them for generating nonhistorical data. The methodology will also serve as a mathematical transfer for handling distributions not conforming to any standard distributions without getting into third and fourth order moments. (K. Singh)

3355 Agronomy. Statistical Applications. Statistical Techniques and Designs: Evaluation and applications of new statistical techniques and experimental designs for Agronomic Research. (W. Walker)

3358 T Business Administration. Rice Standards and Grades. Evaluating the objectivity and effectiveness of the standards and grading system for rice in the Dominican Republic. (A. Beato)

3360 Political Science. Pisciotte-Johnson Illinois Legislature. The changing character of the Illinois legislature is the focus of the project. Further, can underlying trends be discerned within the data which will provide consistant threads to explain turnover among legislators? This will be the main question. (K. Johnson)

3362 Entomology. Linear Regression Analysis. I am executing dosage mortality probit analysis on data obtained from treating german cockroaches with various combinations of insecticides and synergists. The program obtains the weighted linear regression of probits on log dose by the maximum likelyhood procedure described by D. J. Finney in Probit Analysis (Cambridge University Press, 1952). (J. Dunwoody)

3363 T Business Administration. Mixed Methods Techniques. A comparative study of simultaneous-equation estimation methods using prior information. (S. Montasser)

3365 Forestry. Mechanical Properties of Wood. The statistical reliability of predicting bending strength of wood from strength-ratio tables. Includes clear-wood strength properties and effects of defects on beam strength. (C. Walters)

3366 T Psychology. A Study of Multidimensional Stimuli. A study of individual reaction multidimensional stimuli under rescrited conditions. (W. Love)

3368 Electrical Engineering. Rocket Data Analysis. Analysis of Faraday Rotation and differential absorption data from Nike Apache rockets. (E. Mechtly)

3370 T Animal Science. Amino Acid Nutrition of Chick. To assess the role of amino acids in the nutrition of the young chick. (D. Baker)

9.3 Class Problem Specifications

During the fourth quarter of 1969, 94 problem specifications were submitted to cover all assigned problems on the System/360 in the following courses.

3053	Mechanical Engineering 286.
3058	Civil Engineering 335.
3059	Civil Engineering 435.
3060	Electrical Engineering 330.
3061	Political Science 328.
3062	Nuclear Engineering 401.
3063	Economics 476.
3064	Aeronautical and Astronautical Engineering 241.
3065	Aeronautical and Astronautical Engineering 334.
3067	Chemistry and Chemical Engineering 421.
3069	Civil Engineering 352.
3074	Theoretical and Applied Mechanics 431.
3075	Theoretical and Applied Mechanics 438.

3078 Sociology 185.

3079 Sociology 201.

3080 Mechanical Engineering 185.

3081 Economics 467.

3085 Theoretical and Applied Mechanics 311.

3087 Aeronautical and Astronautical Engineering 414.

3090 Nuclear Engineering 451.

3092 Education, College of 459.

3094 Psychology 332.

3095 Department of Computer Science 999.

3096 Electrical Engineering 415.

3097 Electrical Engineering 322.

3102 Astronomy 401.

3103 Theoretical and Applied Mechanics 425.

3105 Aeronautical and Astronautical Engineering 254.

3112 Civil Engineering 306.

3117 Civil Engineering 478.

3118 Electrical Engineering 498.

3120 Theoretical and Applied Mechanics 493.

3122 Electrical Engineering 352.

3128 Finance 254.

3129 Finance 350.

3130 Mathematics 365.

3131 Electrical Engineering 229.

3132 Psychology 306.

3134 Theoretical and Applied Mechanics 293.

3135 Theoretical and Applied Mechanics 493.

3141 Department of Computer Science 109.

3142 Agricultural Economics 220.

3144	Mathematics 149.
3151	Survey Research Laboratory 999.
3154	Mechanical Engineering 458.
3157	Mechanical Engineering 408.
3160	Industrial Engineering 282.
3161	Industrial Engineering 355.
3166	Electrical Engineering 497.
3167	Physics 498.
3169	Industrial Engineering 386.
3170	Department of Computer Science 490.
3171	Psychology 455.
3172	Educational Psychology 497.
3173	Sociology 185.
3183	Anthropology 220.

3197 Astronomy 491.

3201 Finance 427.

3203 Electrical Engineering 350.

3209 Education, College of 490.

3212 Civil Engineering 314.

3217 Chemistry and Chemical Engineering 348.

3218 Geography 495.

3220 Psychology 306.

3221 Dairy Science 205.

3264 Mathematics 149.

3266 Electrical Engineering 497.

3267 Civil Engineering 497.

3286 General Engineering 241.

3291 Business Administration 380.

3296	Civil Engineering 369.
3297	Civil Engineering 284.
3301	Aeronautical and Astronautical Engineering 213.
3308	Aeronautical and Astronautical Engineering 254.
3309	Agricultural Engineering 221.
3312	Civil Engineering 261.
3314	Architecture 348.
3315	Psychology 480.
3318	Mathematics 315.
3319	Urban Planning 437.
3334	Veterinary Physiology and Pharacology 392.
3343	Communications 490.
3347	Department of Computer Science 201.
3350	Chemistry and Chemical Engineering 406.

3352	Mathematics 249.
3356	Agronomy 440.
3357	Psychology 493.
3359	Astronomy 322.
3361	Illinois College Mathematics 398.
3364	Psychology 235.
3367	Business Administration 552.
3369	Mechanical Engineering 250.
3371	Educational Psychology 490.
3372	Educational Psychology 490.

10. GENERAL DEPARTMENT INFORMATION

10.1 Personnel

The number of people associated with the Department in various capacities is given in the following table:

	Full-time	Part-time	Full-time Equivalent
Faculty	24	1	24.50
Visiting Faculty	7	0	7.00
Research Associates	2	0	2.00
Graduate Research Assistants	6	99	61.77
Graduate Teaching Assistants	0	21	9.92
Professional Personnel	41	3	43.17
Administrative and Clerical	29	0	29.00
Nonacademic Personnel (Monthly)	78	0	78.00
Nonacademic Personnel (Hourly)	2	118	45.80
TOTAL	189	242	301.16

The Department Advisory Committee consists of Professor J. R. Pasta, Head of the Department; Professor J. N. Snyder, Associate Head of the Department; Professors E. K. Bowdon, K. W. Dickman, L. D. Fosdick, H. G. Friedman, C. W. Gear, D. B. Gillies, D. J. Kuck, B. H. McCormick, S. Muroga, T. A. Murrell, J. Nievergelt, R. S. Northcote, J. R. Phillips, W. J. Poppelbaum, S. R. Ray, J. E. Robertson, P. E. Saylor, and D. L. Slotnick.

10.2 Bibliography

During the fourth quarter, the following publications were issued by the Laboratory:

File Numbers

(1) Budnik, P. and Kuck, D., "A TRANQUIL Programming Primer," File No. 816, December 10, 1969.

(2) Franco, S., "A High Speed Analog Divider for the Illiac III Scan System," File No. 810, October 3, 1969.

(3) Henschen, L., "Resolution, Merging, Set of Support and Tautologies," File No. 817, December 16, 1969.

(4) Lopeman, H. and Miller, R., "Data Disc Control Graphics 8," File No. 818, December, 1969.

(5) Northcote, R., "Some Software Considerations in Utilization of a Network of Computers," File No. 815, November 21, 1969.

(6) Yasui, T., "Double Precision Arithmetic Routine for Illiac IV," File No. 813, October 8, 1969.

Report Numbers

(1) Atkins, D., "Illiac III Computer System Manual: Arithmetic Units. Volume I," Report No. 366, December 1969.

(2) Carter, C., Hostovsky, R., Levin, H., Lopeman, H. and Miller, R., "Graphics 8: Graphics Hardware - 1469 Gear," Report No. 371, 1969.

(3) Chawla, M. and Jain, M., "Line and Area Orthogonality of Jacobi Polynomials," Report No. 369, December, 1969.

(4) "Illiac IV -- Quarterly Progress Report -- July - September, 1969," Report No. 362, November 1, 1969.

(5) Kuck, D. and Lawrie, D., "The Use and Performance of Memory Hierarchies: A Survey," Report No. 363, December 4, 1969.

(6) Schwebel, J., "Graph Transformations for Composite Formations," Report No. 368, December 12, 1969.

(7) "SOUPAC -- Statistically Oriented Users' Programming and Consulting," Report No. 370, December, 1969.

Theses

(1) Ellis, Clarence A., "Probabilistic Languages and Automata," (Ph.D.), Report No. 355, October, 1969.

(2) Goddard, David M., "Weather Analysis on a Parallel Computer," (M.S.), Report No. 365, December 1, 1969.

(3) Grothe, David M., "A Macro-Assembler for Illiac IV," (M.S.), Report No. 364, December 1, 1969.

(4) Guth, Gary R., "Functional Device Models and Computer Aided Circuit Design," (M.S.), Report No. 361, December 1, 1969.

(5) Harms, Richard P., "Modeling of Domain Growth Activity in Polycrystalline Ferrites," (M.S.), Report No. 358, November, 1969.

(6) Machado, Nelson C., "ISL-A Semantics Language for a Translator Writing System," (M.S.), Report No. 367, December 11, 1969.

(7) Mulvey, John M., "A Nonlinear Programming Algorithm for an Array Computer," (M.S.), Report No. 357, October 22, 1969.

(8) Pavis, Denise C., "ICL: A Control Language for Illiac IV," (M.S.), Report No. 356, October 13, 1969.

(9) Ring, David, "BUM-Bundle Processing Machine," (M.S.), Report No. 353, October, 1969.

(10) Rollenhagen, David C., "The Vista System for Compression of Television Signal Bandwidths," (Ph.D.), Report No. 354, October, 1969.

10.3 Colloquia

"Design of a Programming Language for Fluid Dynamics Problems," by Professor John M. Gary, National Center for Atmospheric Research, Boulder, Colorado, October 6, 1969.

"Picture Processing," by Dr. Antonio Grasselli, University of Pisa, Pisa, Italy, October 14, 1969.

"The Arithmetic Complexity of Certain Functions," by Dr. S. Winograd, The Thomas J. Watson Research Center, Yorktown Heights, New York, October 20, 1969.

"Singular Points of Parameterized Functional Equations," by Professor Joel Davis, Oregon State University, Corvallis, Oregon, October 27, 1969.

"Computer Recognition of Three-Dimensional Objects in a Visual Science," by Professor Adolfo Guzman, Massachusetts Institute of Technology, Cambridge, Massachusetts, November 3, 1969.

"OSCAR: Oregon State Conversational Aid to Research," by Professor Joel Davis, Oregon State University, Corvallis, Oregon, November 7, 1969.

"Level Structure, An Implemented Abstraction," by Professor A. N. Habermann, Carnegie-Mellon University, Pittsburgh, Pennsylvania, November 17, 1969.

"Synchronization of Parallel Processes," by Professor A. N. Habermann, Carnegie-Mellon University, Pittsburgh, Pennsylvania, November 18, 1969.

"The STAR Computer for the Grand Tour," by Professor Algirdes Avizienis, Jet Propulsion Lab., University of California at Los Angeles, California, November 24, 1969.

"Fault Tolerant Computers," by Professor Algirdes Avizienis, Jet Propulsion Lab., University of California at Los Angeles, California, November 25, 1969.

"EXDAMS-Extendable Debugging and Monitoring System," by Dr. Robert M. Balzer, Computer Science Department, The RAND Corporation, Santa Monica, California, December 15, 1969.

10.4 Drafting

During the fourth quarter, a total of 557 drawings were processed by both drafting sections:

	General	Pattern Recognition
Large Drawings	9	81
Medium Drawings	108	29
Small Drawings	167	67
Layouts	1	2
Report Drawings	5	6
Changes	23	26
Miscellaneous	6	27
TOTAL	319	238

(M. Goebel and S. Zundo)

10.5 Shops' Production

Job orders processed and completed during the fourth quarter of 1969 are as follows:

	AEC 1018	AEC 1469	Other
Machine Shop	7	11	11
Electronics Shop	3	59	13
Chemical Shop	2	53	6
Layout Shop	5	51	7
TOTAL	17	174	35

(F. Serio)

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